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Solid Waste Incineration at Lima Army Tank Plant, OH

by
Kenneth E. Griggs

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The Life Cycle Cost in Design (LCCID) computer program was used to compare economic data for incineration versus continued landfilling.

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Although constructing an incinerator would require a high capital cost, evaluation indicates that burning materials shredded onsite offers the lowest life cycle cost and may qualify for the Productivity Enhancing Capital Investment Program (PECIP). If a tipping fee discount of greater than 50 percent could be obtained from the demolition landfill in return for buying back shredded material, this option may be the most economical. A shared savings program should also be considered to fund this project.

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FOREWORD

This study was performed for the Lima Army Tank Plant, Lima, OH under Project Order 4A-8-OSU08-4A-MB by the Energy and Utility Systems Division (ES) of the U.S. Army Construction Engineering Research Laboratory (USACERL). Mr. Greg Hueber, AMSTA-CL was the Technical Monitor.

Mr. K.E. Griggs was the Principal Investigator. Dr. Dave Jonich is Chief, USACERL-ES. The technical editor was Gloria J. Wienke, USACERL Information Management Office.

COL Daniel Waldo, Jr. is Commander and Director of USACERL, and Dr. L.R. Shaffer is Technical Director.

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SOLID WASTE INCINERATION AT LIMA ARMY TANK PLANT, OH

1 INTRODUCTION

Background

Many areas of the United States are experiencing shortages of landfill space for solid waste disposal (Figure 1). The problem is becoming more severe in Ohio as waste is being shipped in from New York and New Jersey. Presently, the Lima Army Tank Plant in Allen County, OH, is disposing of its wastes through a contractor at a commercial landfill. The cost of using commercial landfills continues to increase, and the rate of increase is expected to escalate as landfills become more scarce. The waste paper and wood generated at Lima represent a potential source of renewable energy. The technical and economic feasibility of recovering that energy must be considered when evaluating disposal options.

Lima is interested in burning waste paper and wood to avoid the rising cost of landfilling. The rapidly rising costs in west central Ohio are partially due to public opposition to siting new landfills. This opposition is highly organized; participants refer to themselves as "Dumpbusters" and they oppose both incineration and landfilling of municipal solid waste. Additionally, the State of Ohio and the U.S. Environmental Protection Agency (USEPA) are imposing more stringent environmental requirements that increase the construction and operating costs of all types of new landfills.

Due to public opposition to burning municipal solid waste, Lima is interested in burning only paper and wood waste. Attempts to burn any other wastes would be strongly opposed by the Dumpbusters. Currently, the paper and wood are going to a demolition landfill in the area. Other wastes are being shipped 35 miles away to the landfill in Miller City, OH.

An evaluation of burning paper and wood waste for energy recovery is naturally linked to Lima's central boiler plant, which consists of five boilers. Units 2, 3, and 4 are spreader stoker/dump grate boilers rated at 20,000 lb/hr*, 25,000 lb/hr, and 50,000 lb/hr, respectively. Units 5 and 6 are Laclede brand chain grate stoker boilers rated at 75,000 lb/hr and 50,000 lb/hr, respectively. It is Lima's intention that units 5 and 6 be the most used, even for low summer loads, because they are newer, they have better controls, and they are attached to a baghouse. Summer steam loads at Lima range from 7,000 lb/hr to 14,000 lb/hr with an average of 10,000 lb/hr.

Lima has submitted a request for Military Construction (DD 1391, document number PN 4916037 SP #1), to construct a retrofit of their existing boilers with a shredding and conveying system to burn the paper and wood wastes. The economics of this project have been disputed by the U.S. Army Materiel Command (AMC) Installation and Support Activity (I&SA) (AMXEN-IU). In addition, I&SA also believes that waste disposal costs in the area will not increase as projected and that the private sector will respond with alternate disposal methods when prices rise high enough. At I&SA's suggestion, Lima engaged the U.S. Army Construction Engineering Research Laboratory (USACERL) to evaluate the technical and economic feasibility of incinerating solid waste.

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*A metric conversion table is on page 25.

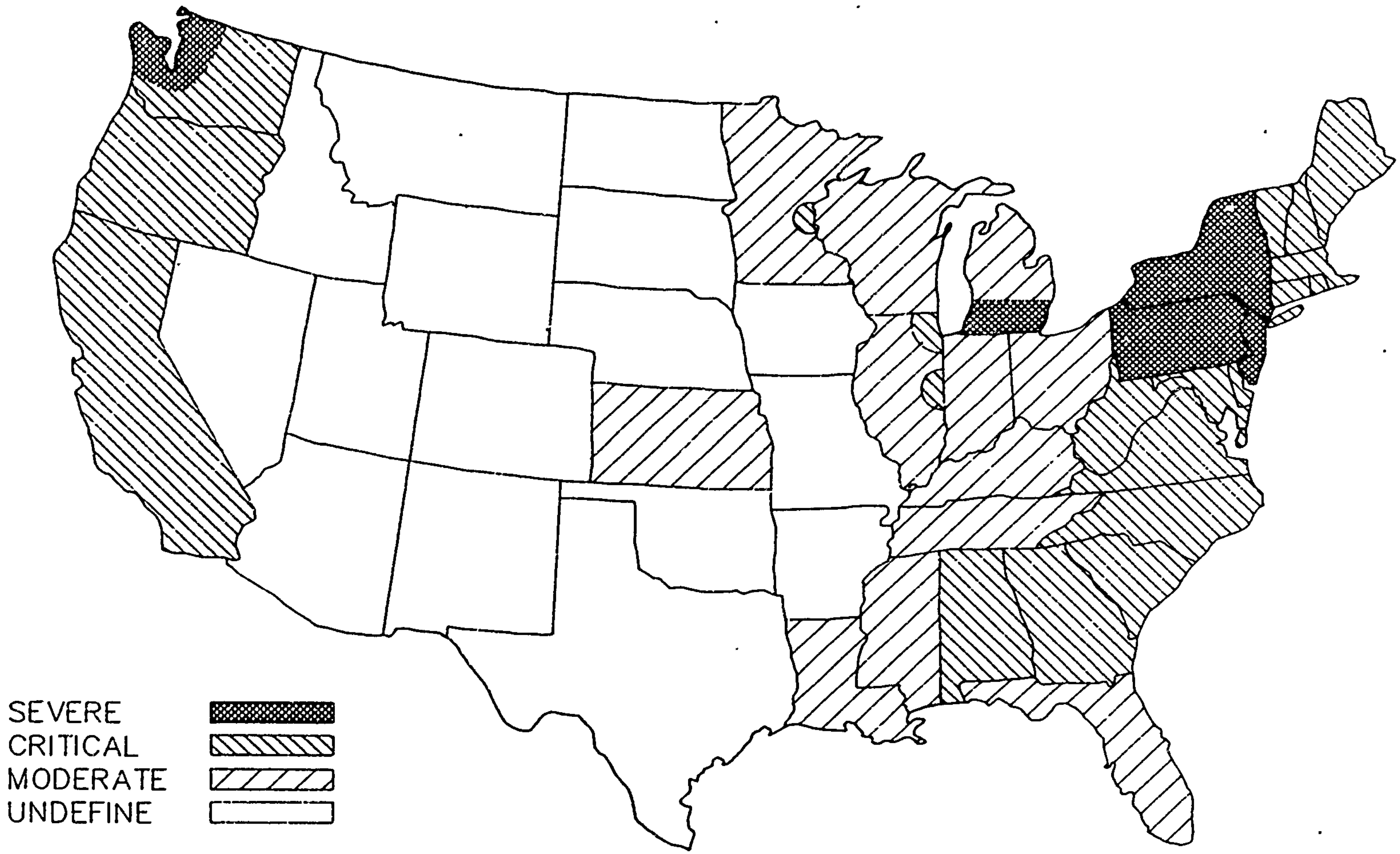

Figure 1. Landfill shortage areas.

Objective

The objective of this project was to determine the technical and economic feasibility of using incineration for solid waste disposal at Lima Army Tank Plant, including justification for any capital expenditures.

Approach

Researchers conducted a literature search and pursued telephone contacts with equipment manufacturers to identify all technically feasible alternatives Lima could use for waste incineration. Technical advice and assistance in developing capital and operating costs were obtained from Schmidt Associates Inc. Information on landfill cost escalation for Ohio was obtained from Lima personnel and compared to national averages. Prospects for recycling were also examined.

The economic data for incineration versus continued landfilling was then analyzed using the Life Cycle Cost in Design (LCCID) computer program. The LCCID program was developed by USACERL to provide life cycle cost analysis and comparative economic evaluation of construction alternatives. The appropriate economic criteria, including Department of Energy (DOE) fuel price escalation rates and present worth calculations, are included in LCCID. The program yields the life cycle cost of each alternative (in this case, continuing to landfill or incineration), the savings to investment ratio (SIR), and the discounted payback period (DPP). The calculation procedures and the format of the output have been approved by the Office of the Chief of Engineers (OCE), DOE, and the National Institute of Standards and Technology (NIST) for Federal government life cycle cost analysis. The output from the program can be used when preparing the Project Development Brochure and DD 1391. It will also give an indication, through the DPP, whether the Quick Return on Investment Program (QRIP) or Productivity Enhancing Capital Investment Program (PECIP) may be funding options. These funding options require a payback of no greater than 2 years or 4 years, respectively. Additional information on the LCCID program is available in USACERL Technical Report E-85/07.[1]

Mode of Technology Transfer

It is recommended that information in this report be used by Lima and AMC to finalize the retrofit project for a shredding and conveying system to burn paper and wood wastes.

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[1] Linda Lawrie, *Development and Use of the Life Cycle Cost in Design Computer Program*, Technical Report E-85/07/ADA 162522 (U.S. Army Construction Engineering Research Laboratory [USACERL], November 1985).

2 RESULTS

State and County Waste Disposal Plans

Mr. Michael Greenberg of the Ohio EPA was contacted concerning the waste disposal situation in the state. The most recent governing legislation is referred to as H.B. 592. It requires individual counties or groups of counties (Solid Waste Management Districts) to establish solid waste disposal plans. Allen County is in a group that includes Champaign, Hardin, Madison, Shelby, and Union Counties (Figure 2). Allen and three of the other counties currently do not have any sanitary waste disposal facilities and must ship their wastes to other areas. Several attempts to establish a new sanitary landfill in Allen County have been defeated due to strong public opposition. The demolition landfill accepting paper and wood from Lima appears to be the only one of that type in the region.

The chairman of the Solid Waste Management District (SWMD) is Mr. Henry Hollenger, the Allen County Sanitary Engineer. Mr. Hollenger reports that the district has engaged the services of Woolpert Associates as consultants to survey the various sources of waste in each county, and develop the waste management plan. The SWMD expects the report from Woolpert in June 1991 and must approve and submit the draft plan to the state for approval by December 1991. Initiation of management projects by the SWMD would occur after state approval of the plan in 1992. Mr. Hollenger also confirmed the strong and adamant opposition of environmental groups in the Allen County area to any kind of sanitary landfill or incineration.

Commercial Landfilling

Mr. Michael Greenberg of the Ohio EPA indicated H.B. 592 may not allow a demolition landfill to accept materials that are not truly construction demolition debris. Mr. M. Tackit, the owner of the demolition landfill, assured researchers that the provisions of his permit do allow him to accept the corrugated packaging material and wood from Lima. However, new state and Federal regulations are requiring him to install a clay liner and make other improvements in the operation. This will cause the tipping fee to increase from \$2.50/cu yd to \$3.50/cu yd (\$6.92 to \$9.69/ton) and later to \$6.50/cu yd (\$18.00/ton). In March 1990, he was not accepting corrugated paper since he did not have a place to store it. He was separating that material and sending it to a recycler. He is constructing a storage building that essentially will be a low level material recovery facility (MRF). Besides removing corrugated paper from the waste stream, he will also be removing wood and running it through a shredder for volume reduction to conserve space in his landfill.

While discussing other possible uses for the wood, Mr. Tackit was asked if he might be interested in taking Lima's wood, shredding it, and "selling" it back to Lima along with additional wood for Lima to burn in their boilers. He responded that he is very interested in finding other uses for wood to help conserve valuable and expensive space in the landfill. He said that he would discuss the subject with Lima. Mr. Tackit was also asked if a reduced tip fee could be given for the corrugated paper if it was separated from the wood when it arrived. He does not believe any industrial operation can get its workers to reliably separate waste materials.

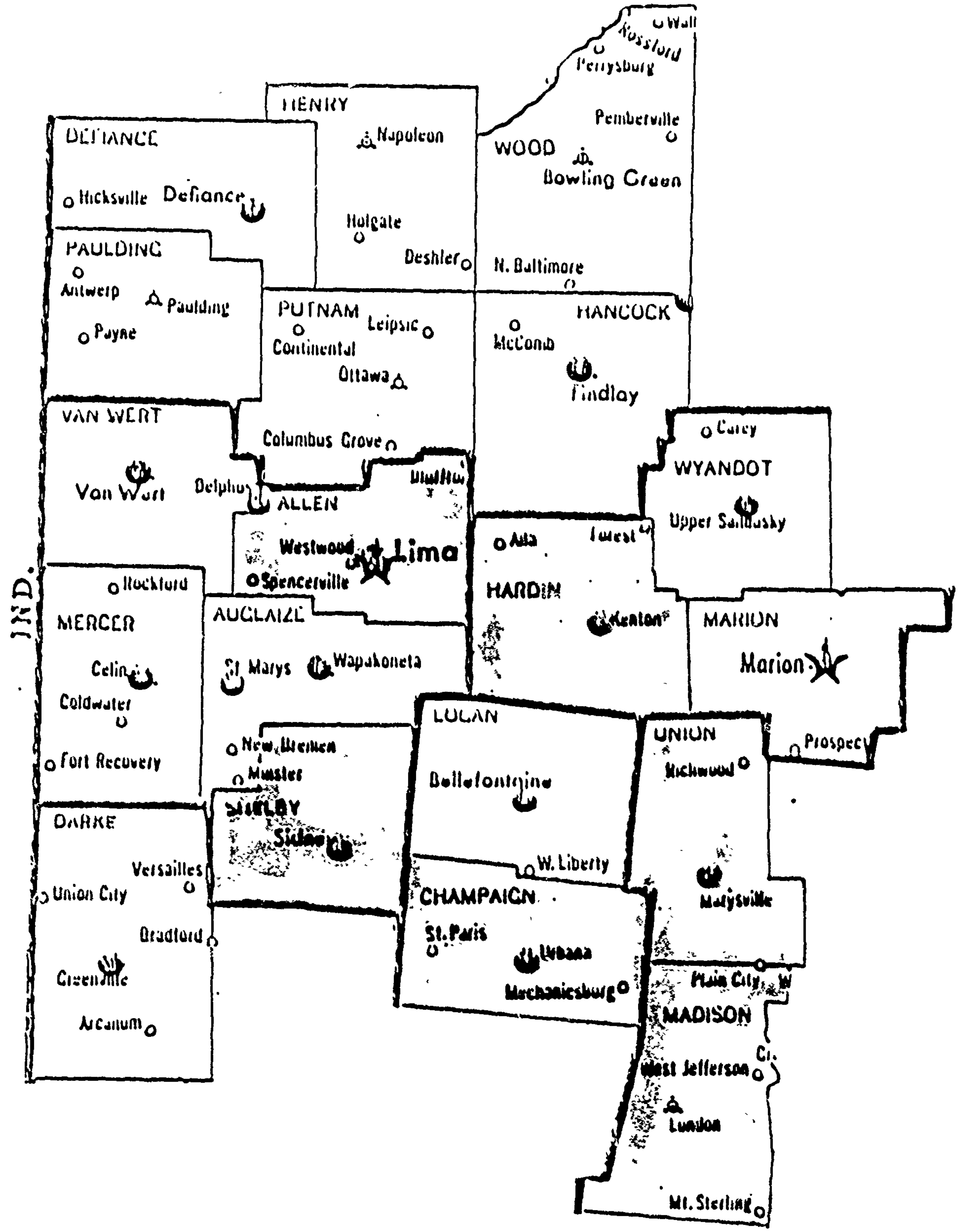

Figure 2. The Solid Waste Management District containing Allen County.

Recycling

The solid waste disposal management plans of most states require recycling to the maximum extent possible. Public pressure from environmental groups also emphasizes recycling. In many cases, states will not issue a permit to burn waste unless it can be shown that recycling is being done or is not feasible. USACERL arranged for Waste Management Incorporated (WMI) to examine the situation at Lima and make recycling recommendations. WMI toured the facility on 14 November 1988 and produced a report (Appendix A) indicating a significant amount of recycling and waste minimization already is occurring at Lima. Some past efforts at recycling old corrugated paper were unsuccessful. High labor costs, a limited market for scrap wood, and relatively low costs at the demolition landfill make recycling wood impractical. It was recommended that formal recycling programs be established for office/computer paper and materials in the cafeteria waste stream.

Original Cofiring Design

The cofiring system originally envisioned by Lima (Figure 3) consists of a shredder, a hammermill, a magnetic separator, two belt conveyors, a bucket conveyor, a 100 cu yd storage bin, a pneumatic conveying system to each boiler, and auger feeders for each boiler (five units). The cost of this system was estimated to be approximately $2,000,000.

To asses the feasibility of cofiring, researchers contacted commercial installations that were burning waste wood and paper along with coal to learn about their experiences. A General Motors (G.M.) plant in Pontiac, MI was burning about 250 tons per day (TPD) of waste along with coal. That operation is about ten times the size of operation that Lima wanted. Mr. Kenneth Griggs of USACERL and Mr. Raju Penmatcha of AMC I&SA visited the plant on 12 October 1989 to observe the technical and economic feasibility of the operation. A copy of the trip report is in Appendix B. The ducting for the pneumatic conveyor at the G.M. plant goes to one boiler, but it may be diverted to an adjacent unit by changing a spool piece in the ductwork. The shredded waste is fed into the coal-fired spreader stoker boiler through the secondary air openings. Most of it burns in suspension. The waste feed is held constant and the coal feed is varied to meet changing steam demand. At times, during low load, the boiler being fed the waste was being fired on almost 100 percent waste. However, G.M. doesn't like firing on 100 percent waste because a coal bed helps maintain the fire. Initially the operation was not economical, but rising waste disposal and coal costs have made it economical.

USACERL Cofiring Design

Researchers investigated a shred-and-burn alternative. This operation involves shredding paper and wood onsite and feeding the material to the boilers. Based on experience at the G.M. plant, a hammermill would be capable of achieving the required waste size reduction. However, shredder sales representatives and Schmidt Assoc. indicate that the power consumption required for a small hammermill would be excessive. Two rotating disk shredders would be required to produce the required 1-in. by 1-in. size. Schmidt Assoc. believes that the shredder models suggested by Shred Pax, a commercial manufacturer, would not be able to handle the waste, and may present a danger to the operator. They do not recommend this option. However, Shred Pax asserts that their units will handle pieces of wood up to 4 in. by 4 in. and be perfectly safe to operate. It should also be possible to convey the shredded waste to the storage bin pneumatically rather than by a bucket conveyor.

The proposed distribution system to each boiler has a number of elbows and tees. Each of these provides an opportunity for the waste to plug the line. Since boilers 5 and 6 will be the ones used most

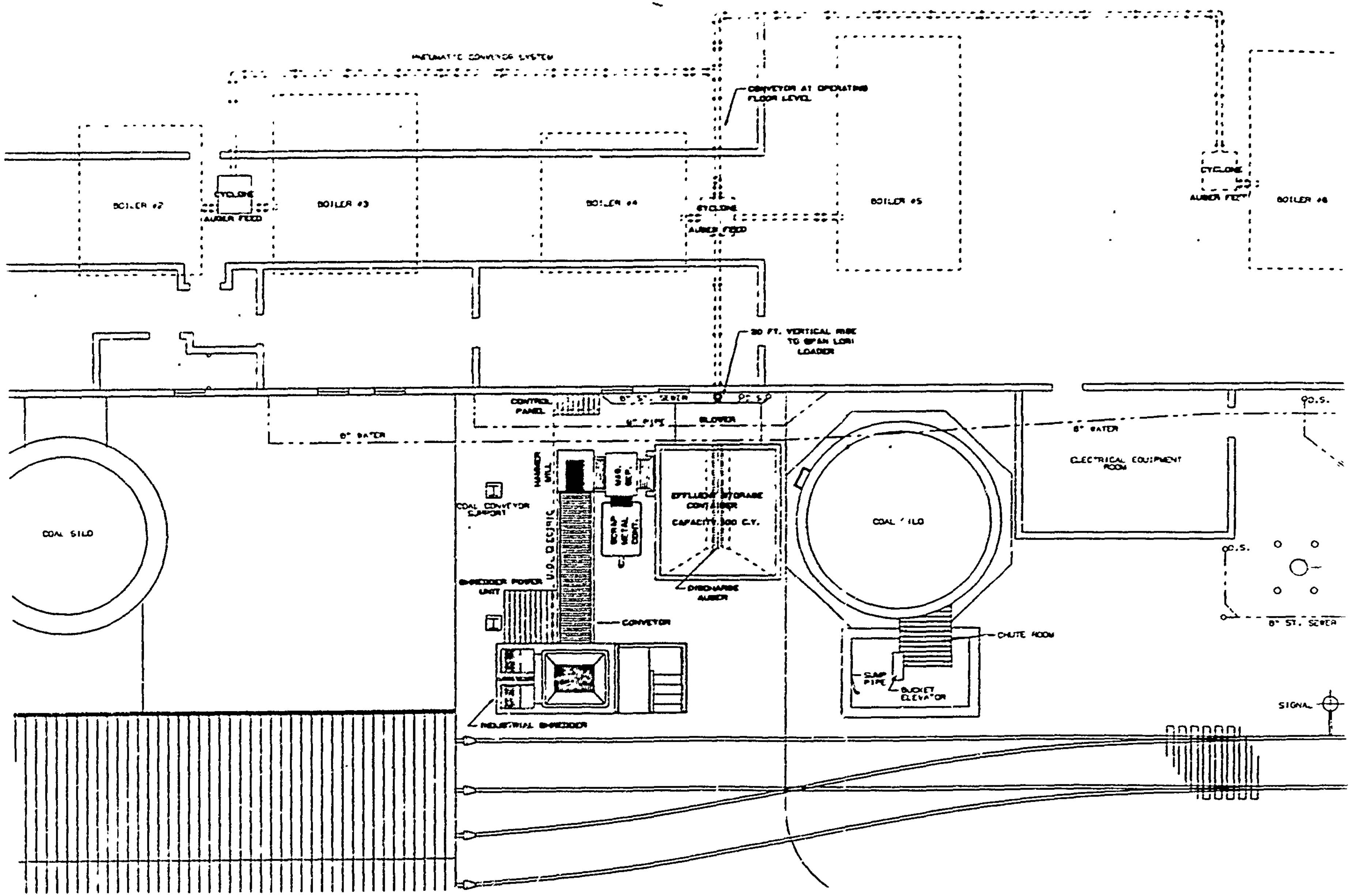

Figure 3. Original cofiring design.

often, all of the waste should go to one with a provision to switch to the other if needed. This design, called Alternative A, is illustrated in Figure 4. Schmidt Assoc. suggested that instead of using an auger to feed waste into boilers 5 and 6, the waste be dropped into the lorries with the coal. However, cost estimates show that an auger feeder arrangement would be less expensive due to modifications that would have to be made to the weigh lorry system. Both USACERL and Schmidt Assoc. are concerned about whether paper would completely burn in suspension in the Lima boilers. Partially burned paper could cause fires in the ash collection system. Comments and installation cost estimates from Schmidt Assoc. are in Appendix C.

Table 1 presents combustion calculations for the coal typically fired in boiler 6 at full load, for 25 TPD of wood, and for 25 TPD of wood plus enough coal to produce the heat required for full load. The relative weights of the two fuels for this last case are 55 percent coal and 45 percent wood. There is only a slight increase in the total amount of flue gas (5.8 percent by weight), but a 22.2 percent reduction by weight and 22.6 percent reduction by lb/MBtu in sulfur dioxide (SO_2) emissions. Increased combustion of wood relative to coal would reduce SO_2 emissions further. Emission factor data published by the USEPA[2] indicate that nitrogen oxide emissions will also decline.

Alternate Cofiring System

As indicated above, the owner of the demolition landfill is planning on shredding all on the wood received and would be willing to sell back to Lima as much as they could use. If this is done, the shredding, magnetic separation, size classification, and some conveying equipment could be omitted from the design. Also, the amount of waste wood fed to each boiler could be increased, and boilers 5 and 6 could both burn wood as a partial substitute for coal. A cost for just the feeding and storage equipment was extracted from Schmidt Assoc. data and incorporated as part of the input to the LCCID program. The cost of truck transportation between the landfill and Lima is expected to be minimal. The financial attractiveness of this option is also related to any special, discounted tipping fee rate that could be negotiated with the demolition landfill in return for buying the wood chips. Two variations of this option are illustrated in Figures 5 and 6: weigh lorry feed (Alternative B) and auger feed (Alternative C).

Schmidt Assoc. commented that the capacity of either boiler to burn wood may be limited by the volume of the weigh lorry, if that is the feeding mechanism. They also expressed concern about whether the grate heat release rate will become excessive in the case of auger feed (see Appendix C). The calculations assume that the waste will be burning in a very small area (9 sq ft). If any type of fuel gets concentrated into a relatively small area, the grate heat release rate will be exceeded and the ash will slag, possibly damaging the grate. The grate could also be damaged by an insufficient amount of ash to insulate it from the heat of the burning fuel. USACERL researchers expect that the waste fuel from the auger will spread out to some extent and not land in such a discrete area. The analysis does emphasize the importance of spreading out the waste fuel, to combine with the coal, across as much of the grate surface area as possible. The exact location of the auger feeds will be very important.

[2] *Compilation of Air Pollutant Emission Factors, Volume I, Stationary Point and Area Sources*, Fourth Edition, Report No. AP 42 (U.S. Environmental Protection Agency [USEPA], September 1990).

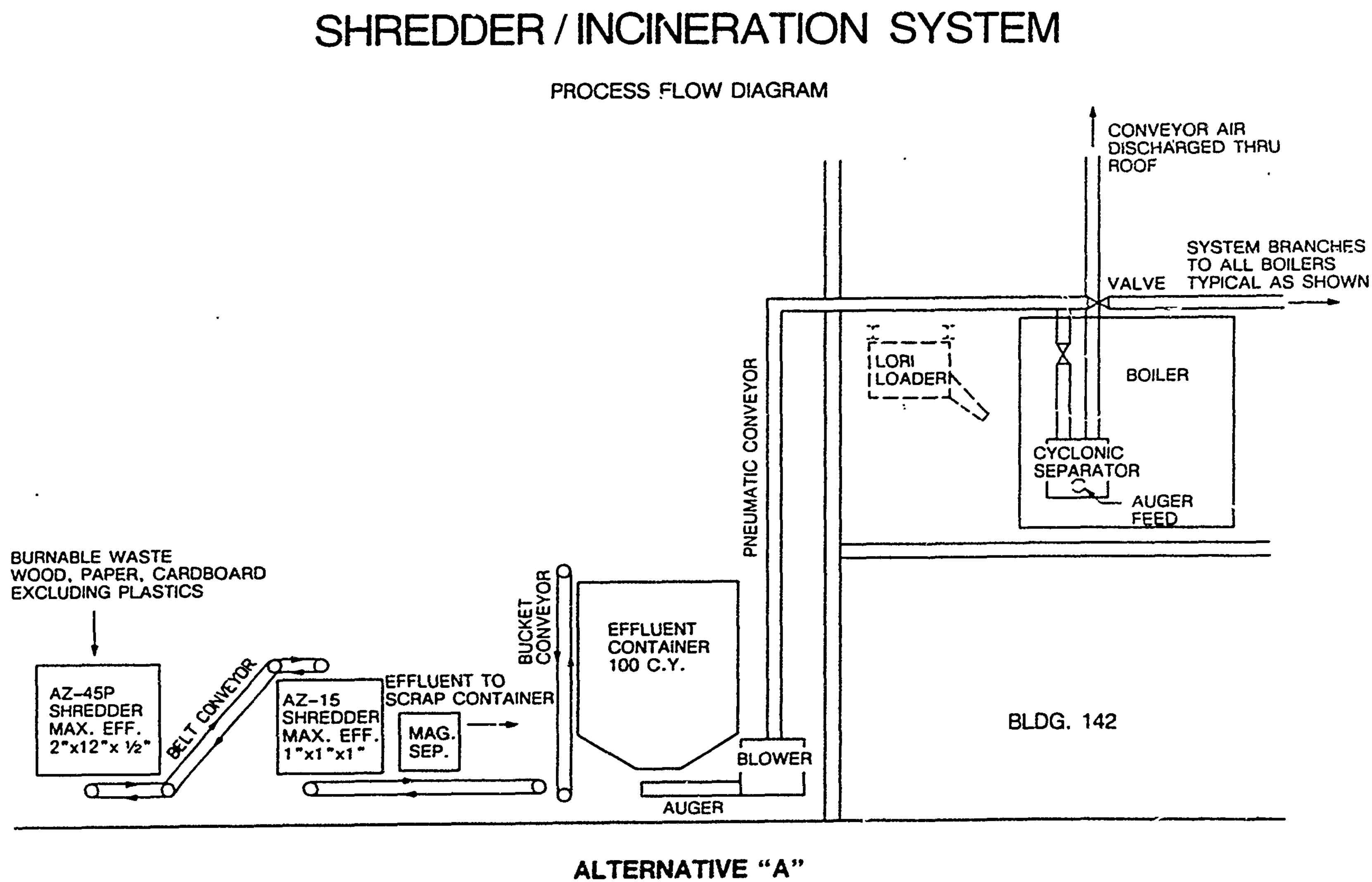

Figure 4. USACERL cofiring design (Alternative A).

Table 1

Combustion Calculations: No. 6 Boiler

Fuel	Coal	Wood	55%C/45%W
ANALYSIS %			
Carbon	74.67	37.60	57.96
Hydrogen	4.86	4.00	4.48
Oxygen	7.50	6.25	6.94
Nitrogen	1.52	20.68	10.15
Sulfur	0.76	0.07	0.45
Water	4.10	30.00	15.77
Ash	6.59	1.40	4.25
Chlorine	0.00	0.00	0.00
TOTAL	100.00	100.00	100.00
Theoretical Air	9.990	5.446	7.944
COMBUSTION PRODUCTS lb/lb			
CO_2	2.738	1.379	2.125
Nitrogen	7.692	4.392	6.206
Water	0.478	0.660	0.561
SO_2	0.015	0.001	0.009
HCl	0.000	0.000	0.000
TOTAL	10.924	6.432	8.902
FLUE GAS lb/hr			
HHV (Btu/lb)	13374	6384	10223
Heat Release	47236968	13297872	47240483
Fuel Fired	3532	2083	4621
Theoretic Air	35283	11345	36710
Excess Air, %	53	53	53
Excess Air	18661	6000	19456
Actual Air	53944	17345	5667
Air Leakage, %	0	0	0
Air Leakage	0	0	0
TOTAL DRY AIR	53944	17345	56167
CO_2	9671	2872	9821
Nitrogen	27168	9149	28680
SO_2	54	3	42
HCl	0	0	0
Fuel Moist.	1690	1375	2592
Air Moist.	701	225	730
TOTAL MOIST.	2391	1600	3322
Ash	233	29	196
TOTAL DRY GAS	55554	18024	57999
TOTAL WET GAS	57945	19625	61321
FLUE GAS ACFM			
Temperature, °F	400	400	400
Pressure PSIA	14.7	14.7	14.7
CO_2	297	682	2333
Nitrogen	10156	3420	10722
SO_2	9	0	7
HCl	0	0	0

Table 1 (Cont'd)

Combustion Calculations: No. 6 Boiler

Fuel	Coal	Wood	55%C/45%W
Excess Air	6736	2166	7023
Leakage Air	0	0	0
Moisture	1389	930	1930
TOTAL FLOW	20587	7198	22014
EMISSIONS			
Oxygen, %	7.37	7.26	7.34
SO_2, lb/MBtu	1.137	0.219	0.880
SO_2, PPM	426	66	309
HCl, PPM	0	0	0
Ash, gr/dscf	2.303	0.884	1.858

Separate Incinerator

Another alternative that should be considered is adding a separate incinerator for burning wastes (Alternative D). This equipment would typically be a modular, starved air unit (Figure 7) with the first, or primary (lower) chamber, operating under substoichiometric (starved air) conditions. The secondary (upper) chamber operates under excess air conditions, completes the combustion of the gases from the primary chamber, and destroys most potential pollutants. Under the current regulations in most states, no additional air pollution control equipment would be needed. However, new regulations in some states, such as New Jersey, New York, Illinois, Oregon, California, and Washington, would require additional equipment, primarily an acid gas scrubber and a baghouse. Many other states are considering similar regulations.

The hot gases from the secondary chamber could be ducted into one or both of the existing boilers. The only air pollution control equipment would be that already connected to the exhaust of the boiler. The air quality permit application would be based on a net reduction in emissions, due to displacing coal, as noted earlier. Equipment cost information has been obtained from the Comtro Division of the John Zink Co. for their model A-45, and is listed in Table 2. This unit has a feed opening of approximately 4 ft by 4 ft and would not require any prior processing of the waste. This alternative would not require any additional personnel to be hired; the present utility staff can feed the waste into the incinerator and operate the controls. Although Schmidt Assoc. feels that an A-45 would not be large enough, the John Zink Co. asserts that this model will burn up to 25 TPD of waste with a heat content up to 8000 Btu/lb. A construction cost was obtained from Schmidt Assoc., and the equipment cost for the A-45 substituted for the A-48 (Appendix C).

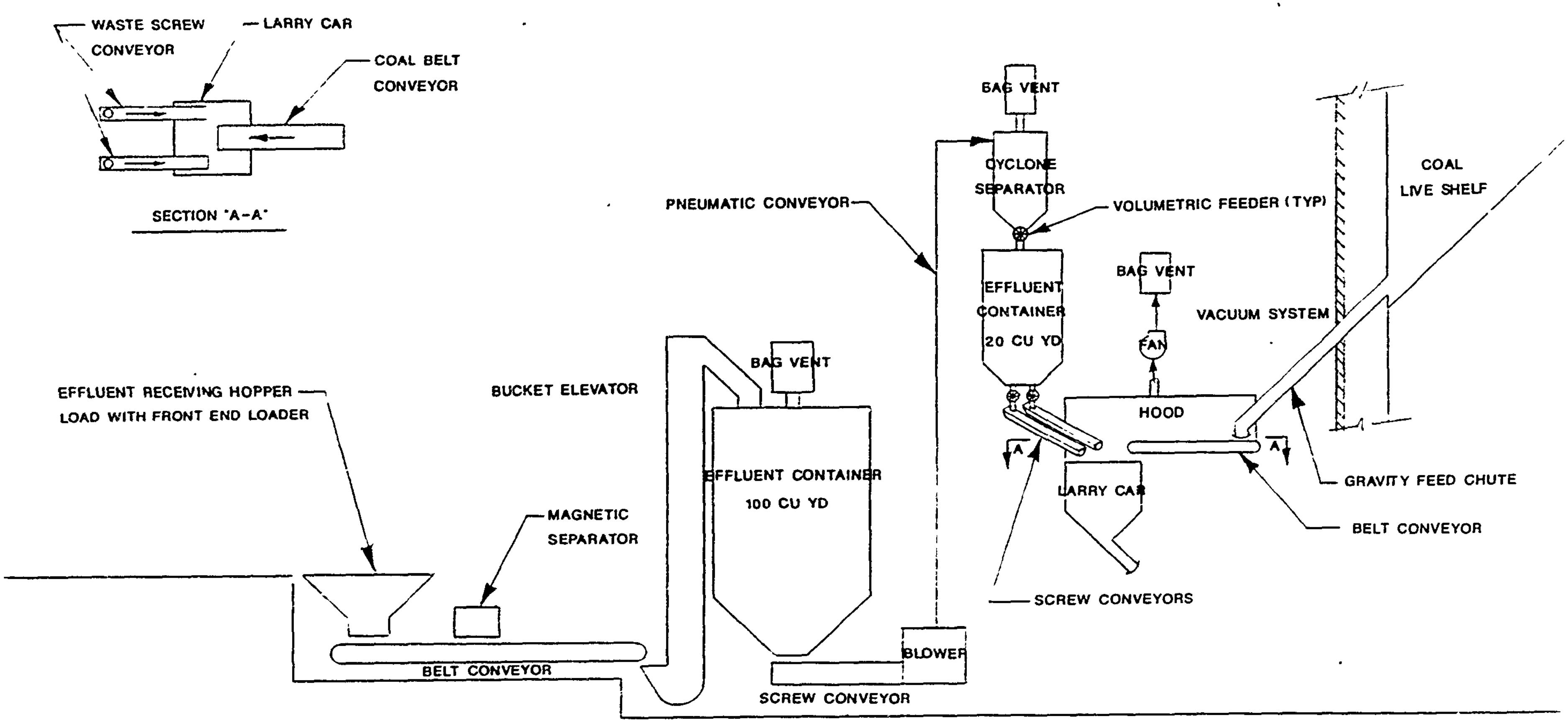

Figure 5. Cofiring design with lorry feed (Alternative B).

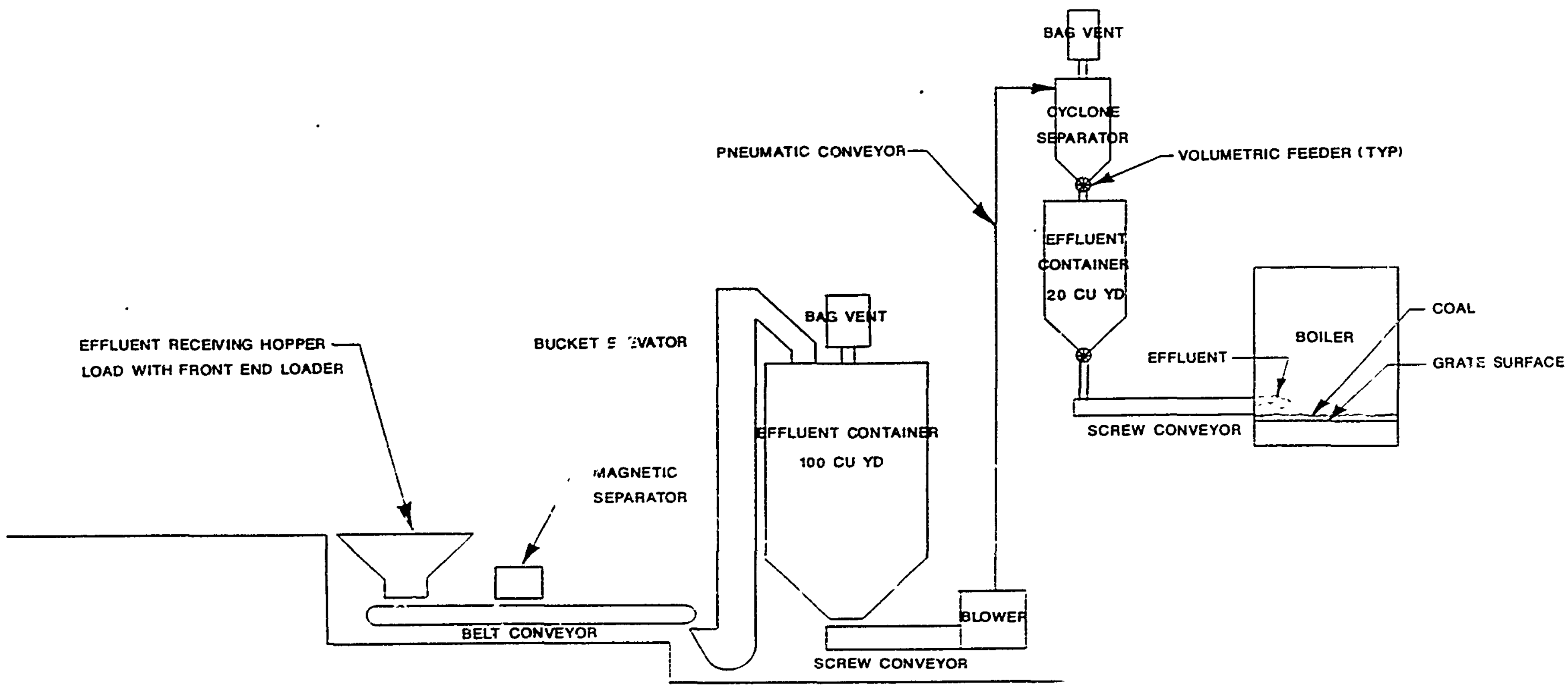

Figure 6. Cofiring design with auger feed (Alternative C).

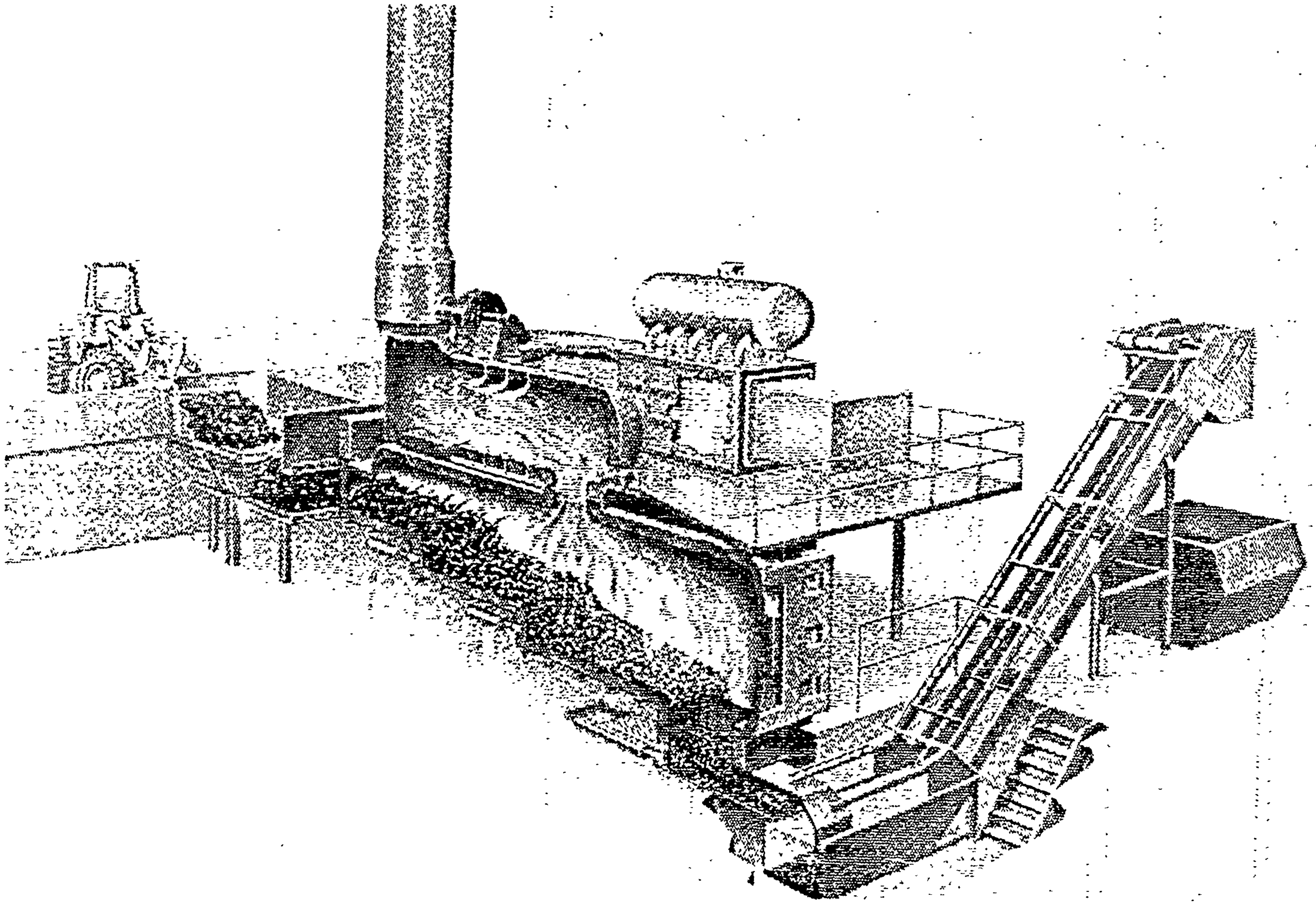

Figure 7. A typical starved air incinerator.

Table 2

Waste Combustion Cost Estimates

Item	Shred & Burn*	Burn Only I**	Burn Only II**	Incinerator
Equipment Capital Cost	$350,000	$277,500	$262,000	$450,000
Construction/Installation	$59,200	$59,200	$59,200	$94,800
Equipment Rehabilitation	$94,500	$94,500	$42,500	$42,500
Building and Conversion	$434,693	$337,606	$279,353	$614,715
TOTAL	$938,393	$768,806	$643,053	$1,327,015

* Modification to Lima's original design by feeding only to Boilers 5 and 6, using the weigh lorries for feeding into the boilers, and using pneumatic conveying systems.
**Continue sending wood to the landfill, receiving shredded wood back from them, and burning larger amounts of wood.

Schmidt Assoc. commented that this alternative would not allow the boiler to be turned down as much as needed while firing coal because a minimum amount of coal is needed on the grate to maintain a fire. The hot gases from the incinerator offset part of this amount of coal. The USACERL technical analysis of the incinerator alternative can be found in Appendix D. It is estimated that the hot gases from the incinerator will only produce 7239 lb/hr of steam because this type of system has a low efficiency due to the combustion not being as complete, and excess air levels being higher, than in typical fossil fueled boilers. This will require that during periods of low load (late March through early October), the rest of the steam will have to be produced by a gas burner. Coal firing will be limited to the remaining months. Conversations with Schmidt Assoc. revealed that the boiler operators at Lima are presently having difficulty achieving the required turndown and a supplemental gas burner may soon be required. Thus, a steam discharge system is included in the cost estimate for each of the alternatives.

Table 3 presents USACERL's calculations for estimating the amount of heat that would have to be produced by gas. Using the steam load curve produced by Schmidt Assoc., the average amount of steam that would have to be produced for various times was determined. It was also assumed that each month consists of 4 weeks with steam being required an average of 6 days per week for a total of 192 hours per month. Boiler efficiency was taken as 82 percent and the available heat in the steam as 975 Btu/lb. This results in an estimate of 15 063 MBtu/yr, including incinerator auxiliary fuel, being required from gas burners. Detailed steam load information would be needed to get a more accurate number.

Economic Analysis

One of the main points of disagreement between Lima and I&SA is the future cost of landfilling. Discussion has centered on the percentage rate of growth of the waste disposal cost. I&SA believes that the cost growth will average only 5 percent, with market forces stepping in to control that growth. Lima believes that the growth will be much larger, amounting to as much as 300 percent over several years.

Table 3

Estimate of Heat Produced From Gas

March - May	((14,000+2,761)/2)(192)(1.667)	=	2,682,296 lb
May - June	((2,761+10,261)/2)(192)(0.667)	=	833,825 lb
June - Aug	(10,261)(192)(2)	=	3,940,224 lb
Aug. - Sep	((10,261+7,761)/2)(192)	=	1,730,112 lb
Sep - Mid-Sep	((7,761+2,761)/2)(192/2)	=	505,056 lb
Mid-Sep - Oct	((2,761+14,000)/2)(192)(0.833)	=	1,340,344 lb
	TOTAL	=	11,031,857 lb/yr

Heat = (11,031,857)(975 Btu/lb)(1/0.82)(1/1,000,000) = 13,117 MBtu/yr

Total Heat = Boiler + Incinerator = 13,117 + 1,946 = 15,063 MBtu/yr

USACERL has converted the actual disposal costs being experienced at Lima to dollars per ton and plotted the results along with national average numbers developed from surveys conducted by *Waste Age* magazine (Figure 8). Lima's experience is consistent with, and shows the same trend as the national average. Waste disposal costs have been rising ever more steeply. Lima's current costs amount to \$34.89/ton. Costs in some areas of New York and New Jersey are \$120/ton and rising rapidly. New landfills and incinerators in those and nearby states are being successfully opposed by groups similar to Ohio's Dumpbusters. It appears that the cost of waste disposal in the Lima area will continue to increase rapidly and market forces will not have a significant effect in the near future. One estimate, based on Lima's actual costs, showed an increase of \$1.20/cu yd/yr. Researchers fitted a straight line to the most current data to develop a conservative estimate; an average annual increase of \$1.60/cu yd/yr (\$4.43/ton/yr). Unfortunately, LCCID and the economic criteria currently being used to evaluate energy related projects does not directly allow for nonenergy cost escalation factors. Therefore, an annual average increase in waste disposal costs of \$4.43/ton/yr was used to compute a waste disposal cost of \$52.73/ton in 1995 and \$114.65/ton in 2009; an average of \$83.69/ton was used for economic evaluation.

Many of the energy related factors for a separate incinerator would also exist for the cofiring options. A summary of the results of the technical analysis using the USACERL Heat Recovery Incinerator Feasibility (HRIFEAS) program are in Appendix D. This program has been developed to quickly perform the technical and economic analyses of proposed HRI projects. However, since the project for Lima involves cofiring and incineration without a separate heat recovery boiler versus continued landfilling, the capital cost information is not valid and has been computed separately. The operation and maintenance (O&M), landfill, and energy costs/savings are valid for each case. It is usually very difficult to economically justify an incineration project when displacing coal, which costs \$1.90/MBtu (\$50.70/ton) in this case. This is why HRIFEAS does not have coal as a displaced fuel option. The displaced fuel was entered as residual oil in the HRIFEAS program at the correct price and manually entered as coal in the LCCID analysis. It was also assumed that ash disposal costs would be equal to the waste disposal costs even though ash disposal currently costs a little less. Table 4 shows miscellaneous calculations for amount of waste available, operating hours, and shredder and conveying fan horsepower.

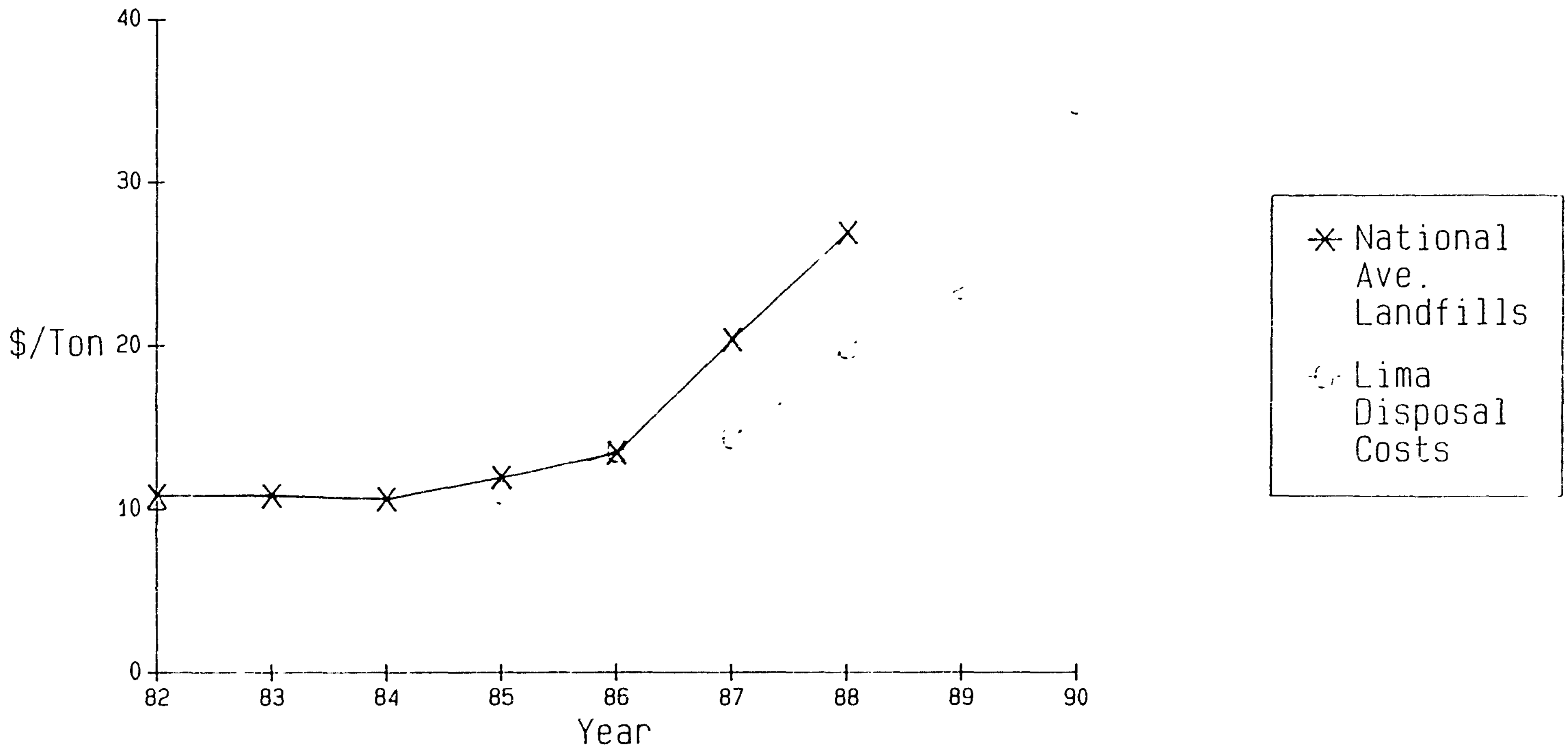

Figure 8. Tipping fee trends.

Appendix E contains the cost estimate (from a representative of the Shred Pax Corp.) for the equipment to shred and burn the waste wood and paper based on the USACERL design. Table 1 lists the capital cost information obtained from the Comtro Division of the John Zink Co for the incinerator alternative. Schmidt Assoc. has provided an estimate (Appendix C) of the total installation cost for the basic USACERL cofiring design (Alternative A, shred-and-burn), the two variations of the alternate cofiring design (Alternatives B and C, burn only), and the separate incinerator design (Alternative D). However, the design fee listed (8 percent) is too low and has been revised to the Corps standard of 25 percent. The cost information supplied to the LCCID program is listed in Table 5. The O&M cost for continuing to landfill the waste disposal cost that would be avoided if the waste was burned. In addition, it was assumed that the project would be funded in Fiscal Year 1993 (FY93), with a midpoint of March 1994, a beneficial occupancy date of March 1995, and a 15-year economic life. It was also assumed that only part of the landfill cost would be avoided (50 percent) with the "burn only" alternatives. The cost estimating department of the Institute of Gas Technology (IGT) recommended a maximum of 10 percent of the equipment capital cost as a reasonable estimate for the annual maintenance and repair costs of the shredders and material handling and feeding systems. Table 6 shows the results of the LCCID analysis.

Table 4

Miscellaneous Calculations

Wood = (13 lb/cu ft) (27 cu ft/yd) (ton/2000 lb) = 0.1755 ton/cu yd
5.698 cu yd/ton

Corrugated* = (35 lb/cu ft) (27 cu ft/yd) (ton/2000 lb) = 0.4725 ton/cu yd
2.1164 cu yd/ton

Annual Amount of Waste = 36,000 cu yd/yr

Wood = 15% = 5,400 cu yd/yr = (5,400)(0.1755) = 947.7 ton/yr

Paper = 25% = 9,000 cu yd/yr = (9,000)(0.4725) = 4,252.5 ton/yr

Total = 14,400 cu yd/yr = 5,200.2 ton/yr

Specific Volume = 14,400/5,200.2 = 2.769 cu yd/ton

Operational Hours = (52 wks/yr)(5 day/wk)(3 shift/day)(8 hr/shift)
= 6240 hr/yr

AZ 45 + AZ 15 Shredders = 20 + 40 = 60 Horsepower

Conveyors & Fans = 48 Horsepower

Shred & Burn	=	(60+58)(42.2 Btu/HP min)(60 min/hr)(6240 hr/yr)(MBtu/10^6 Btu)
	=	1864 MBtu/yr
Burn Only I	=	(58)(42.2 Btu/HP min)(60 min/hr)(6240 hr/yr)(MBtu/10^6 Btu)
	=	916 MBtu/yr
Burn Only II	=	(47)(42.2 Btu/HP min)(60 min/hr)(6240 hr/yr)(MBtu/10^6 Btu)
	=	743 MBtu/yr
Coal	=	$50.70/Ton & 13,374 Btu/lb
	=	($50.7/Ton)(Ton/2000 lb)(lb/13374 Btu)(10^6 Btu/MBtu)
	=	$1.90/MBtu

*Compacted

Table 5

LCCID Program Input

Item	Status Quo (Landfill)	Shred & Burn	Burn Only I	Burn Only II	Incinerator
Capital Cost	0	$1,086,103	$883,525	$737,978	$1,535,897
Electrical Consumption MBtu/yr)	0	1864	916	743	674
Coal Consumption (MBtu/yr)	56,466	0	0	0	0
Natural Gas Consumption (MBtu/yr)	0	0	0	0	15,063
O&M Cost					
Maint. & Repair	0	$42,450	$31,200	$24,450	$130,000
Waste Disposal	$261,113		$130,557	$130,557	
Waste Fuel Cost			$1300	$1300	
TOTAL	$261,113	$42,450	$163,057	$156,307	$130,000

Table 6

Results of LCCID Analysis*

Alternative	LCC	SIR	DPP
Landfill (Status Quo)	$3,439,000	Base	Base
Shred and Burn	$1,543,000	2.9	4
Weigh Lorry Burn Only	$2,368,000	2.3	5
Auger Feed Burn Only	$2,159,000	2.9	4
HRI	$3,573,000	0.9	19

*Costs are in 1990 dollars with a discount rate of 7%.

3 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This research indicates that incineration is a technically and economically feasible method of solid waste disposal at Lima Army Tank Plant. Despite the cost of new equipment and required maintenance, incineration is and will continue to be the most economical method due to rapidly rising landfill costs. Based on national trends, it is unlikely that waste disposal market forces in the Lima area will exert sufficient influence to stabilize landfill costs.

Of the four alternatives for solid waste disposal evaluated using the Life Cycle Cost in Design program, Alternative A (shred and burn) has the lowest life cycle cost. With a payback of 4 years, the project may qualify for the Productivity Enhancing Capital Investment Program (PECIP).

The option of burning already shredded waste using an auger feeder (Alternative C) has the same savings to investment ratio and discounted payback period as the shred-and-burn alternative. If a tipping fee discount of greater than 50 percent could be obtained from the demolition landfill in return for buying back the shredded material, this alternative would be the most economical.

The equipment costs indicate that Lima's original idea of shredding only its own waste and burning it on site could be installed at a significantly lower price than originally estimated. Of the options analyzed, the separate incinerator (Alternative D) has the highest capital cost at $1,535,897. This alternative is also hampered by the fact that significant amounts of natural gas must be burned to allow for boiler turn-down.

Significant recycling and waste reduction measures have been taken at Lima. Some used pallets are recovered for reuse, scrap metal and aluminum beverage cans are recovered, and an extensive chemical recycling program is in place. However, a limited market for scrap wood and relatively low costs at the demolition landfill make recycling wood impractical.

Initiation of any solid waste management projects will occur after state approval of the draft Solid Waste Management District plan that will be submitted in the fall of 1991. Any new landfills or incinerator plants will probably not begin operation for at least 10 years after that due to required public hearings and resulting court challenges.

Recommendations

Because local markets exist, Lima should initiate recycling programs for office/computer paper and glass, aluminum, steel, plastic, and corrugated material. Lima should stay in contact with Allen County and the Solid Waste Management District and seek assistance and support in improving recycling and waste reduction efforts. This should include assistance in finding buyers for recycled material. However, Lima and AMC must expect that these markets will become glutted as the total amount of material being recycled in the area increases. This glut may exist for several years before market forces and political action relieve the situation.

It is recommended that Lima and the AMC Installation and Support Activity use the LCCID program for economic analysis of all proposed construction projects. This program is the standard for the Department of Defense (DOD) and can save considerable time and effort. The program is free to all DOD agencies and is periodically revised to reflect the latest economic guidance.

Based on the economic analysis, Lima should talk with the demolition landfill owner to determine if the disposal cost of the waste paper and wood could be reduced by more than 50 percent in return for

Lima buying as much shredded wood as possible. If a greater discount can be realized, the economics need to be reevaluated and the "burn only" option with auger feeders selected if it has the lowest life cycle cost. It should also be noted that at times of low load, one boiler will probably not burn all of the wood that Lima will produce. However, during other times when more than one boiler is on line, more wood than Lima is capable of producing could be burned. In this situation, the demolition landfill would become the surge storage.

If a greater discount on the waste disposal costs cannot be obtained, Lima and AMC should proceed with the Military Construction, Army (MCA) project to install the shredders and other equipment as outlined in this report. Advice from AMC indicates that because of the 4-year payback, Lima should submit a DA 5108 immediately for the PECIP as well as continue with normal MCA procedures.* If the PECIP application is approved, the project will still be MCA funded, but the money will be in addition to the normal MCA allocation.

Consideration should also be given to funding this project under shared savings. Under this program, Lima can enter into a long-term agreement with a contractor to provide cost saving improvements. The contractor is paid by receiving a share of the savings. However, the current actual costs and future expected costs must be accurately documented since this is the basis for payments to the contractor. Because changes in the operation of Lima are possible, the contract should include the option to "buy out" the contractor's investment in the event changes significantly reduce the savings from the project. Lima can issue the contract directly, with the approval of AMC and technical input from Huntsville Division. Huntsville is the shared savings center of expertise.

If shredders are procured, the specification needs to clearly state the amounts, type, and sizes of materials to be shredded. The shredder manufacturer must also be required to give assurances of personnel safety. The augers must be carefully selected and located to provide the maximum dispersion of waste across the grate in order to avoid hot spots. Emphasis should be on burning wood; great caution should be exercised when burning paper in order to avoid fires in the baghouse.

Metric Conversion Table

1 Btu =	1,054.8J
1 cu yd =	0.765 m3
1 lb =	0.455 kg
1 sq ft =	0.093 m^2
1 ton =	907.2 kg

* Tank Automotive Command, Autovon, 786-8866

APPENDIX A: WASTE MANAGEMENT INC. REPORT

RECYCLE AMERICA
A Waste Management Company

Waste Reduction/Recycling Tour
Site: U.S. Army Tank Plant - Lima, Ohio
Date of Tour: November 14, 1988

Tour site representatives present: Tom Ansley, Cleat Hoersten, Bob Monroe, Rick Turner.

Waste Management representatives present: Jack DeWitt (General Manager-Lima Division), Kevin Vance (Recycling Manager-Lima Division) and Rob McClellon (Recycling Manager-Mideast Region).

Tour initiated by: Ken Griggs (U.S.A. CERL) contacted Waste Management to request this service. Rob McClellon from Mideast Region office followed-up with contact to local Division and Tank Plant Management.

Pertinent background information: U.S. Army Tank Plant in Lima is considering implementing major changes within their solid waste handling practices. Currently a vast majority of waste is placed in various size containers which are emptied and the contents landfilled. A small percentage of the used pallets are accepted by a local company to be repaired and resold. The remainder of the pallets (which are stored in a separate area) are hauled to a local demolition disposal site. WMNA-Lima has the current waste hauling contract.

The change being proposed by the Tank Plant is to incinerate 60-65% (not including the cafeteria waste) of the waste steam on-site. The steam would then be used by the facility.

Before the incineration conversion budget is approved, the existing waste reduction/recycling opportunities were to be explored and evaluated.

Two previous attempts at recycling were made by the Tank Plant. An agreement was made with Allen County Recycling Station to separate corrugate containers (OCC) from the waste stream. Using plant personnel, OCC was separated, flattened and stacked in a 40 foot trailer which was spotted by Allen County Recycling Station. The trailer was filled in three days. The trailer was then removed from the facility without the knowledge of plant management. Attempts to follow-up with Allen County Recycling Station at to the amount of OCC (estimated at two tons by WMNA) and any proceeds have been unsuccessful.

RECYCLE AMERICA
A Waste Management Company

The second attempt was initiated by WMNA-Lima Division. Select loads were transported to the Division facility where they were off loaded on a tipping floor. "Pickers" who were employed by the Lima Division, attempted to pull out all the acceptable OCC. Due to exiting limitations at the Lima Division, this service is presently not being offered.

Current recycling programs in place:

1. Limited used pallet recovery.
2. Metal scrap is recovered, stored and sold.
3. Extensive chemical recycling program is in place.
4. Aluminum beverage cans are recovered by maintenance personnel.

Current waste reduction program in place:

1. Three compactor units (one 4 yard and two 6 yard) exist on the site to reduce the number of containers hauled per week.

Recycling programs being considered:

1. Donating used pallets to employees/Lima residents. Program not implemented due to liability concerns.

2. Used office paper recycling program.

3. Computer paper recovery program.

The following are observations/information discovered during site visit:

1. Annual waste generation: 12,600 compacted yards (as estimated by WMNA)
   22,680 loose yards
   35,280 total yards

2. Estimated composition of waste being hauled: 60% non-recyclable items, 15% corrugated cardboard, 15% office paper and 10% wood. (Note: scrap metals and some pallets are not included as part of this prediction).

3. Number of containers/hauling frequency: see attachment A: site map.

4. Composition within many containers is not consistent from load to load. Where one load one week contains 70% OCC, the next week it may contain 30% OCC.

5. Containers for administrative building are fairly consistent with a high percentage of recoverable used high grade office paper and computer paper.

6. Cafeteria waste is placed in its own container, not mixed with waste from the rest of the facility.

7. A large amount of waste is transported to the containers in plastic bags. This makes composition analysis and recovery of recyclable items difficult.

8. The solid waste stream traffic pattern is well laid out and makes for efficient disposal.

9. High cost of labor is a severe discouragement to implementing a majority of the available recycling options.

Listing of existing recycling/waste reduction opportunities:

1. Office and computer paper recycling program.
2. Waste reduction of used pallets through shredding.
3. Recovery of OCC through separation from the waste stream.
4. Cafeteria Recycling Program.

Evaluation of options:

1. Office and computer paper.

Advantages: There is an existing local market; a significant (meaningful) portion of the waste stream would be reduced; program is easy to put in place; hauling and processing could be handled by an independent company; affected personnel could be easily trained.

Disadvantages: Does take away from productivity; one time start-up costs would have to be absorbed by Tank Plant; storage space needs to be made available.

2. Pallet shredding.

Advantages: Should receive a 5-to-1 size reduction; would decrease the frequency of servicing the container; pallets are currently being separated so no changes to the current practice are necessary.

RECYCLEAMERICA

Disadvantages: One time cost of shredder; fuel and maintenance costs; high cost of labor to operate machinery; with an existing demolition disposal site, costs for disposal are quite low.

3. Recovery of OCC.

Advantages: High generation rates mean a significant reduction in the waste stream; OCC is easy to identify and separate; local market exists.

Disadvantages: High labor costs involved in hauling OCC; time intensive to flatten and stack OCC in a trailer; compactor or bailer could be used but both have a significant one-time cost.

4. Cafeteria Recycling Program:

Advantages: Glass, aluminum, steel, plastic and OCC are all recyclable; local markets exist for recovered materials; cafeteria has separate disposal container which could be segmented; lower labor costs involved in the separation.

Disadvantages: Low generation rates; costs to put in storage units which can be easily emptied at processing center.

Review of Recycling options

	Handling Costs	Equipment Costs	Waste Stream Reduction	Suggestions
Office/computer paper	relatively low	Low	Medium	Go
Used pallets	already included	Medium	High	no-go
OCC	High	Medium	Medium	no-go
Cafeteria	Medium	Medium	Unknown	Go

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Suggestions:

1. Office/computer paper - go
   Why? Costs are low and this is an excellent opportunity to make an impact in the waste steam while recovering a resource.

2. Used Pallets - no go
   Why? High operating costs of union labor. Disposal costs are low because of demolition site.

3. OCC - no go
   Why? This is an option which should be taken advantage of, but high union labor costs hurt the program. In the very near future, as disposal cost continue to rise, this option will make more sense.

4. Cafeteria - go
   Why? This is an easy program to set-up and should be given an attempt. If no significant impact is being made on the program is viewed as not cost effective it can be cancelled with little loss of investment.

Incineration

If disposal comes down to a choice between incineration and implementing recycle/waste reduction programs, I would recommend that recycling/waste reduction first be given an honest attempt.

The reasons for this decision are as follows:

1. Capital costs are quite high for boiler, conveyors and scrubbers.

2. Labor costs would be enormous to: separate the combustible items, transport the items to the conveyor, monitor the feed and be responsible for operation and maintenance.

3. A 90% volume reduction of the combustibles is hoped for. If achieved, the remaining 10% would be added to the 35-40% of non combustibles for 45-50% remaining disposal capacity.

4. Depending on the complexity of the ash from the incinerator, this may cause much higher disposal costs, at least for the 10% residue.

5. Future State and Federal regulations may close down the incinerator at any time or render it ineffective through waste stream flow control of some of the combustibles.

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6. If the cost to separate items is acceptable for incineration, these costs should be acceptable for recycling.

The above list is <u>not</u> to be misconstrued as an attack on incineration, rather a factual review of the situation.

cc: Geoff Older
Jack DeWitt
Rhan Pen Matcha

APPENDIX B: GENERAL MOTORS PLANT TRIP REPORT

CERL-ES 16 OCT 1989

MEMORANDUM FOR Ch, ES
THRU G. Schanche

SUBJECT: Trip Report - G.M. Waste Disposal and Boiler Plant.

1. PURPOSE: to examine how G.M. is shredding and burning wood and paper waste in coal fired boilers.

2. PLACE AND DATE: Pontiac, MI; 12 October 1989.

3. SIGNIFICANT ELEMENTS:

a. The specific G.M. plant visited is disposing of its own wood and paper waste along with waste from other G.M. plants in the area and several other industrial customers.

b. The operation seems to be working very well and is currently providing an economic benefit to G.M.

4. TECHNOLOGIES OPPORTUNITY:

a. Application of the same technology to Lima Army Tank plant.

b. Possible application of this technology to other AMC plants.

5. ATTENDEES: Mr. Robert Wyatt, G.M. Plant Engineer
Mr. Butch Fulton, Boiler Plant Supervisor
Mr. Raju Penmatcha, AMC I & SA, Rock Island Arsenal
Mr. Kenneth E. Griggs, CECER-ES

6. NARRATIVE:

a. We were first briefed by Mr. Wyatt on the history and general characteristics of the operation. they receive waste from other G.M. plants in the area and several outside customers. They only burn wood waste, corrugated cardboard, and some waste paper. Some metal comes in, but they try to minimize the amount received. If a load is rejected, the customer still has to pay as well as dispose of it elsewhere. Source separation is practiced in the G.M. plants. The operation was started in 1975. Although it was not economical at first, it does currently provide an economic benefit. Waste is dumped on a tipping floor and then pushed into a conveyor recessed into the floor. The conveyor transports the waste into the hammer mill shredder. Only one stage of shredding is used to reduce wood as large as 4x4's or tree stumps to approximately 1"x1". Corrugated is also fed to the shredder, but large slugs of regular paper causes problems. The waste is then fed to an air classifier using a vacuum system. Larger pieces of wood and most metal drop out in the classifier and are returned by another conveyor to the tipping floor. The waste is stored in a bell shaped silo that will hold 600 tons. Rotating buckets (sweeps) in the silo remove the waste from the silo and put it into the pneumatic conveying system for feeding into the boilers. Approximately 200 tons per day is burned and there is a significant reduction in coal usage.

b. The waste processing is in its own building. A control room/office looks down onto the tipping floor. The tires of the front loader are foam filled to reduce flats and other damage. Metal shavings have been put into the floor topping material to increase life. The cost of replacement parts is a major economic factor. They turn over the hammers on the shredder after six months and replace them every year. The vibrating conveyors are also a major maintenance item. They have installed a forced oil system for bearings and other parts requiring lubrication. The only magnetic separation is on the end of the conveyor carrying the rejects from the classifier back to the tipping floor. A small baghouse is used to remove the dust from the air used for conveying. A pipe was noticed going around the top of the storage silo. We were informed that it is used to introduce steam to suppress any fires that develop. However, to actually put out the fire, they usually just empty the silo. G.M. feels that the system would probably work better if a magnetic separator were added to further reduce the small amount of metal that does reach the boilers. Although this metal does not create a significant operating problem, they do have to go inside the boiler periodically to clean it out of the grate.

c. The feed piping goes primarily to one of the boilers with the provision to switch to the boiler next to it. Both boilers are spreader stokers. The waste is fed through the secondary air openings above the regular feeders. This blows the waste in just above the coal bed and G.M. estimates that 99% is burned in suspension. The coal feed handles the load swings while the waste feed is held constant. Each boiler has its own basic feed system which receives the waste blown over from the silo. The boiler secondary air is supplied through blue piping to blow the waste into the boiler. A rotating shaft controls the dampers so that each one is puffed in rotation. The splitter mechanism supplying waste to the feed points includes an internal swing spout to insure even distribution. There have been some additional slagging problems with the waste. Each boiler has an economizer. Although each boiler also has a wet scrubber, G.M. buys very low sulfur coal (0.65% S) and pays $47 to $48/ton. I commented on how that is very close to what the Army pays. At times, the boiler being fed with waste has been fired during low load on almost 100% waste. However, they don't like doing that as the coal bed helps maintain the fire.

7. CONCLUSIONS: The waste burning operation at the G.M. plant appears to be a successful example of what Lima Army Tank plant wants to do with their wood and paper waste. However, this example could not be copied exactly at Lima because of the much smaller scale (200 TPD versus 25 TPD) and the possibility of using chain grate stoker boilers instead of speeder stoker boilers. However, the concepts and material handling problems will be very similar.

8. ACTIONS RECOMMENDED: Communicate the above information to Lima Army Tank Plant and use it in the study for Lima. (ACTION: CECER-ES/K. Griggs, 27 OCT 89)

Kenneth E. Griggs
PI, Mechanical Engineer

APPENDIX C: SCHMIDT ASSOC. REPORT

Solid Waste Incineration Study
For
The Lima Army Tank Plant
Lima, Ohio

June 1990

Schmidt Associates, Inc.
Consulting Engineers
7333 Fair Oaks Road
Cleveland, Ohio 44146
(216) 439-7300

The Lima Army Tank Plant (LATP) Lima, Ohio is presently experiencing severe problems associated with the proper disposal of their wood and corrugated paper waste. These problems include escalating costs associated with disposal at commercial landfills due to the dwindling supply of available landfill space. LATP is also interested in utilizing the potential energy from the waste for steam production at their Central Heating Plant.

This report will investigate and review four (4) alternatives to landfilling of the wood and corrugated paper waste, three (3) of which were developed by USACERL, and all of which utilize the potential energy for steam production. Associated cost estimates are given for three (3) of the four (4) alternatives due to the fact that one (1) of the alternatives (Alternative 'A') was deemed impractical.

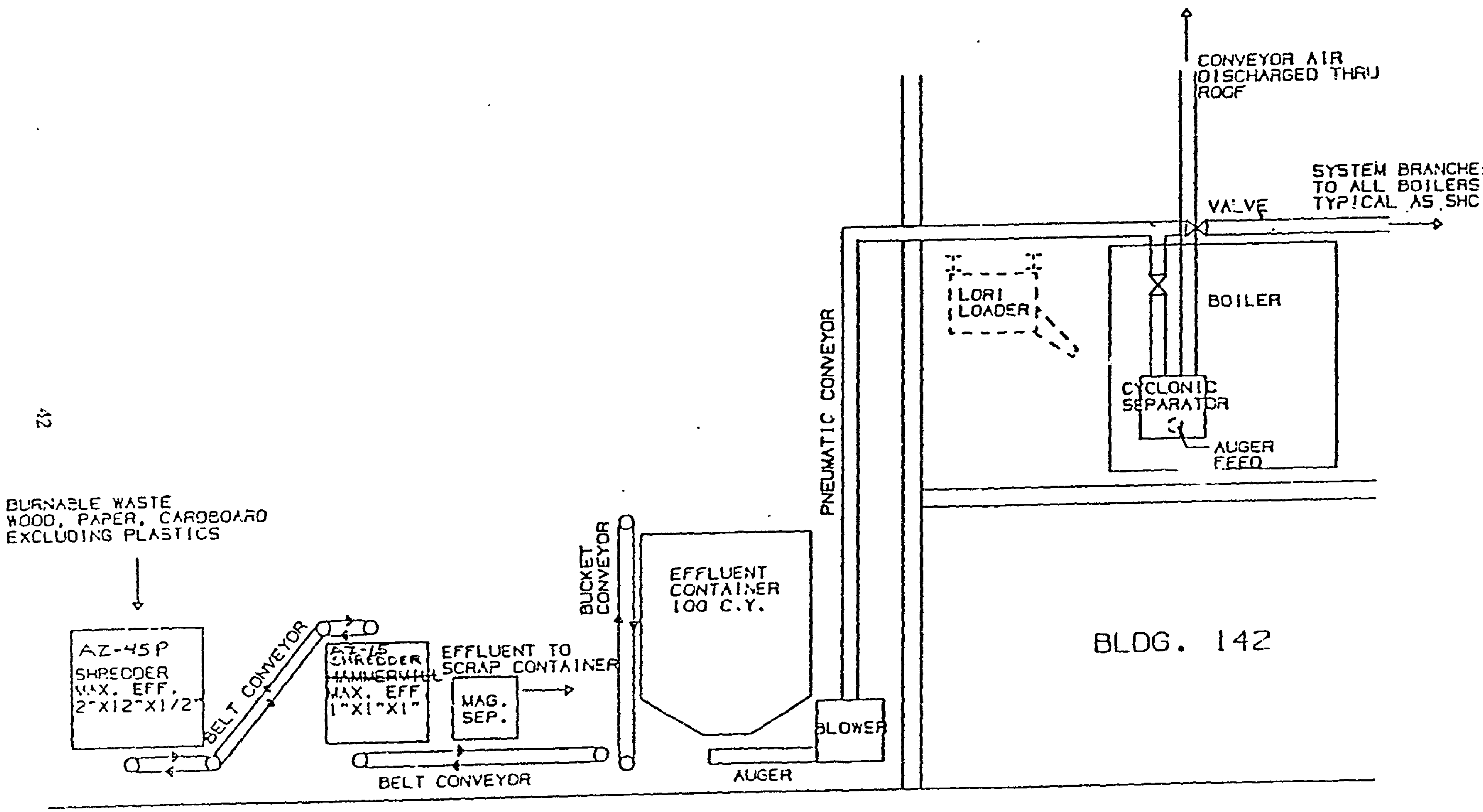
Presently LATP produces 20.23 tons/day of wood and corrugated paper waste in the form of large wooden pallets approximately 4 ft^2 and large corrugated paper boxes. The first three (3) alternatives deal with the idea of co-firing the waste with coal into either of the two (2) chain grate boilers. Alternative 'A', Figure 1, utilizes two (2) large industrial shredders (Shred Pax Models AZ-45P ad AZ-15). These shredders would be operated in conjunction with a series of belt conveyors, a bucket elevator and a feeding mechanism as shown in Figure 1. It is SAI's contention that due to the size of the wood pallets and the corrugated boxes, the shredder feed hoppers will tend to jam frequently. This will disrupt the system flow in addition to creating safety hazards for the operators. Considering the volume of material that will have to flow through the shredders and the logistics involved with ensuring that the proper sized material is obtained, resulted in dismissal of this alternative as a viable solution.

The second alternative (Alternative 'B') utilizes the option of continuing to ship the wood and paper waste to the landfill where it would be shredded into the proper size and returned to LATP at a token price. This would minimize the capital investment required for co-firing the waste with coal in the chain grate boilers in addition to reducing the operating and maintenance costs of the systems.

Alternative 'B', Figure 2, utilizes the existing 4,000 lb weigh larry car as the feeding mechanism for co-firing of waste and coal into either of the two (2) chain grate boilers. The coal and waste mixing is based on a total heat input (Btu/Hr) into the boiler with coal representing 60% of heat input and waste representing 40% of heat input. Figure 3 graphically depicts LATP average monthly steam loads. The following calculations provide the waste burning capacities utilizing this alternative and the steam loads in Figure 3. These capacities are limited to the logistics involved with filling the weigh larry car and feeding the coal/waste mixture into the boiler. It was predetermined that the operator can handle at a maximum one (1) weigh larry car trip every thirty minutes.

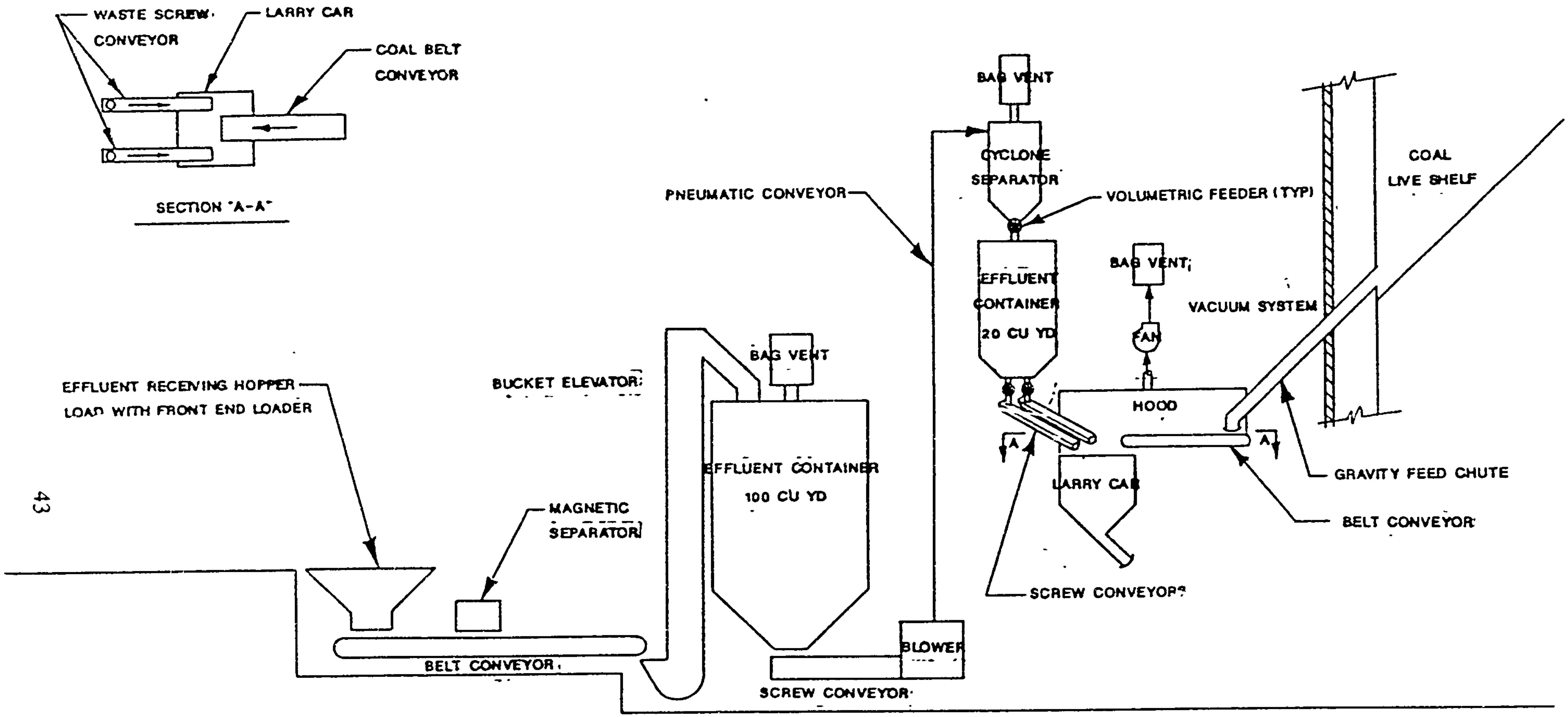
SHREDDER/INCINERATION SYSTEM

PROCESS FLOW DIAGRAM

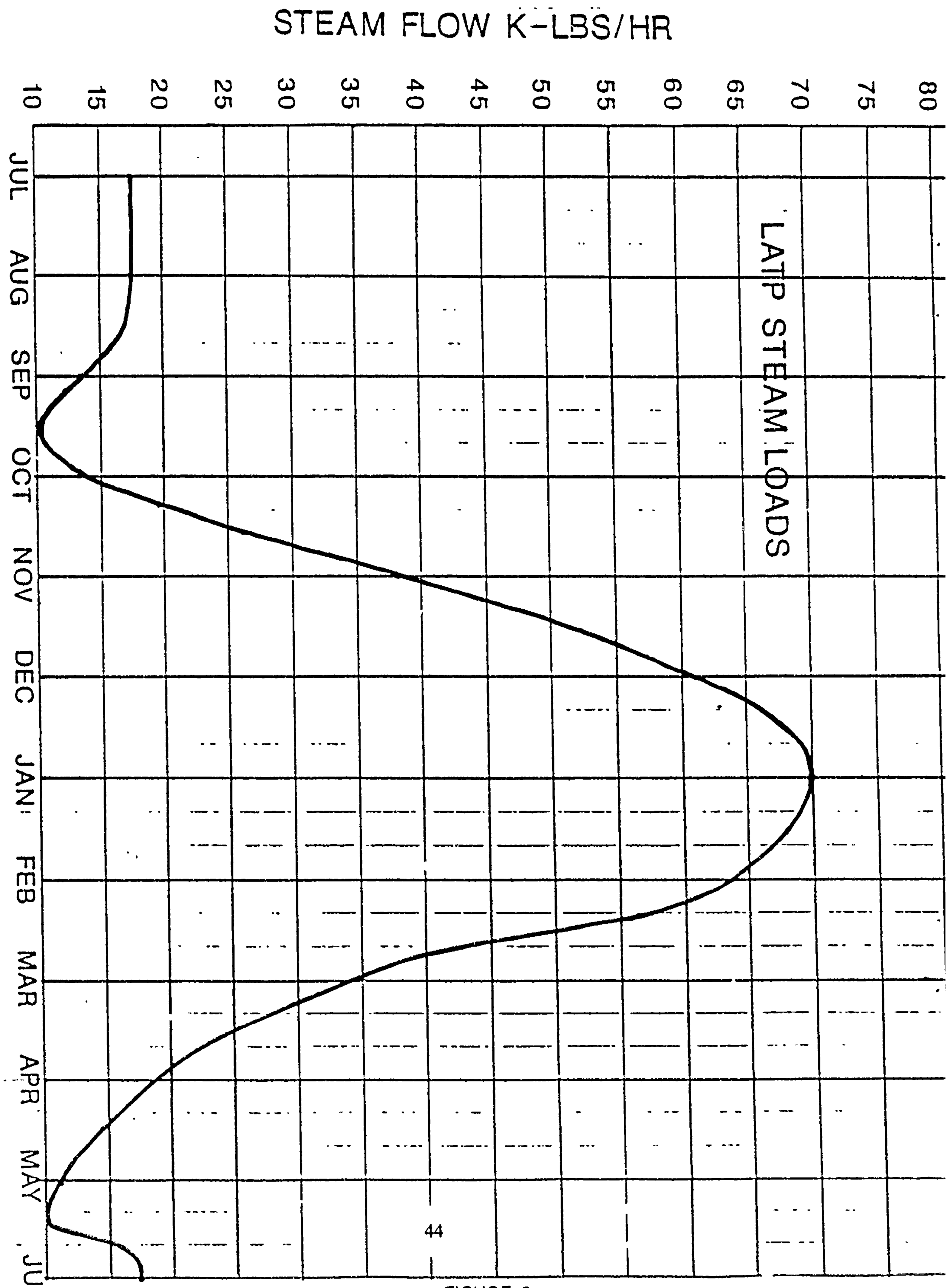


ALTERNATIVE "A"

- 2 -



FIRING PREPARED SHREDDED WASTE
ALTERNATIVE "B"


STEAM FLOW K-LBS/HR
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LATIP STEAM LOADS

FIGURE 3

Alternative 'B'
Waste Burning Capacities
Firing Prepared Shredded Waste
Utilizing Weigh Larry Car

I. Fixed Data:

Efficiency (Boilers 5 & 6)	-	82%
Percent of Heat Input Waste	-	40%
Percent of Heat Input Coal	-	60%
Coal Heat Value	-	13,300 Btu/Lb
Waste Heat Value	-	6,864 Btu/Lb
Enthalpy Steam	-	975 Btu/LB
Capacity Weigh Larry Car	-	72.7Ft^3
Time Duration of Waste Feed	-	24 Hrs/Day 5 Days/Wk
Density Coal	-	55 Lbs/Ft^3
Density Waste	-	15 Lbs/Ft^3

II. Capacity at 14,000 Lbs/Hr Steam Load (Average Sept., Oct., April, May):

A. Heat Input - $\frac{14{,}000 \text{ Lbs/Hr} \times 975 \text{ Btu/Lb}}{.82}$

- 16.6×10^6 Btu/Hr

B. Waste Capacity - $\frac{.40 \times 16.6 \times 10^6 \text{ Btu/Hr}}{6{,}864 \text{ Btu/Lb}}$

- 967 Lbs/Hr

- 11.6 Tons/Day

C. Required Number of Weigh Larry Car Trips Per Hour:

Ft^3 Waste - $\frac{967 \text{ Lbs/Hr}}{15 \text{ Lbs/Ft}^3}$ - 64.5 Ft^3/Hr

Ft^3 Coal - $\frac{.60 \times 16.6 \times 10^6 \text{ Btu/Hr}}{55 \text{ Lbs/Ft}^3 \times 13{,}300 \text{ Btu/Lb}}$

- 13.6 Ft^3/Hr

No. Trips/Hr - $\frac{64.5 + 13.6}{72.7}$

- 1.07

- 1 Trip Every 56 Min.

Alternative 'B' (Cont'd.)

III. Capacity at 17,500 Lbs/Hr. Steam Load (June, July, August):

A. Waste Capacity $= \frac{17.5}{14} \times 967$ Lbs/Hr

$= 1209$ Lbs/Hr

$= 14.5$ Tons/Day

B. Required Number of Weigh Larry Car Trips Per Hour:

Ft^3 Waste $= \frac{1209 \text{ Lbs/Hr}}{15 \text{ Lbs/Ft}^3} = 80.6 \text{ Ft}^3\text{/Hr}$

Ft^3 Coal $= \frac{.60 \times 17{,}500 \text{ Lbs/Hr} \times 975 \text{ Btu/Lb}}{.82 \times 13{,}300 \text{ Btu/Lb} \times 55 \text{ Lbs/Ft}^3}$

$= 17.1 \text{ Ft}^3\text{/Hr}$

No. Trips/Hr $= \frac{80.6 + 17.1}{72.7}$

$= 1.34$

$=$ 1 Trip Every 45 Min.

IV. Capacity at 35,000 Lbs/Hr Steam Load (March and November):

A. Waste Capacity $= \frac{35}{14} \times 967$ Lbs/Hr

$= 2418$ Lbs/Hr

$= 29.0$ Tons/Day

B. Required Number of Weigh Larry Car Trips Per Hour:

Ft^3 Waste $= \frac{2418 \text{ Lbs/Hr}}{15 \text{ Lbs/Ft}^3} = 161.2 \text{ Ft}^3\text{/Hr}$

Ft^3 Coal $= \frac{.60 \times 35{,}000 \text{ Lbs/Hr} \times 975 \text{ Btu/Lb}}{.82 \times 13{,}300 \text{ Btu/Lb} \times 55 \text{ Lbs/Ft}^3}$

$= 34.1 \text{ Ft}^3\text{/Hr}$

No. Trips/Hr $= \frac{161.2 + 34.1}{72.7}$

$= 2.7$

$=$ 1 Trip Every 22 Min.

Alternative 'B' (Cont'd.)

V. Capacity at 26,000 Lbs/Hr Steam Load:

A. Waste Capacity $= \frac{26}{14} \times 967$ Lbs/Hr

$= 1796$ Lbs/Hr

$= 21.6$ Tons/Day

B. Required Number of Weigh Larry Car Trips Per Hour:

Ft^3 Waste $= \frac{1796 \text{ Lbs/Hr}}{15 \text{ Lbs/Ft}^3} = 119.7 \text{ Ft}^3\text{/Hr}$

Ft^3 Coal $= \frac{.60 \times 26{,}000 \text{ Lbs/Hr} \times 975 \text{ Btu/Lb}}{.82 \times 13{,}300 \text{ Btu/Lb} \times 55 \text{ Lbs/Ft}^3}$

$= 25.4 \text{ Ft}^3\text{/Hr}$

No. Trips/Hr $= \frac{119.7 + 25.4}{72.7}$

$= 2.0$

= 1 Trip Every 30 Min.

VI. Utilizing 1 trip every 30 minutes as the maximum expected feed capability, then Yearly Waste Capacity becomes:

A. 21.6 Tons/Day x 30.4 Days/Month x 5 Months (Nov., Dec., Jan., Feb., March) = 3,283 Tons/Yr

B. 14.5 Tons/Day x 30.4 Days/Month x 3 Months (June, July, August) = 1,322 Tons/Yr

C. 11.6 Tons/Day x 30.4 Days/Month x 4 Months (Sept., Oct., April, May) = 1,410 Tons/Yr

6,015 Tons/Yr

VII. Lima Army Tank Plant Produces:

20.23 Tons/Day x 30.4 Days/Month x 12 Months/Year

= 7,380 Tons/Year

This will require exhausting steam to the atmosphere during the months of April, May, June, July, August, September and October to make up a deficit of 1,365 tons/year.

The costs involved with Alternative 'B' are as follows:

Costs for Alternative 'B'
Firing Prepared Shredded Waste

Material	Cost	
28 Ft x 28 Ft Building	$ 39,200.00	
a. Lighting	10,000.00	
b. Foundations	10,000.00	
Effluent Receiving Hopper	5,000.00	
Effluent Belt Conveyor	20,000.00	
Magnetic Separator	10,000.00	
Bucket Elevator	25,000.00	
Effluent Container 100 Yd^3 w/Foundation	25,000.00	
a. Screw Conveyor	10,000.00	
b. Blower	20,000.00	
c. Pneumatic Conveyor	40,000.00	
d. Bag Vent	8,000.00	
Cyclone Separator	10,000.00	
a. Bag Vent	8,000.00	
b. Volumetric Feeder	2,500.00	
Effluent Container (Elevated) 20 Yd^3 w/Structural Steel	12,000.00	
a. (2) Screw Conveyors	20,000.00	
b. (2) Volumetric Feeders	5,000.00	
Coal Gravity Feed Chute w/Loading Valve	20,000.00	
Coal Belt Conveyor	15,000.00	
Weigh Larry Car Vacuum System		
a. Hood	4,000.00	
b. Fan	5,000.00	
c. Bag Vent	8,000.00	
Steam Exhaust System	15,000.00	
Economizer Flue Gas Bypass	7,500.00	
Controls and Interlocks	20,000.00	
Motors, Motor Starters, Etc. 58 Total HP	17,000.00	
Total Material Costs	$391,200.00	
Construction Cost @ 50%	195,600.00	
Subtotal:	$586,800.00	
Construction Cost Contingency @ 15%	88,020.00	
Subtotal:	$674,820.00	
Design Fee @ ~~8%~~ 25%	~~53,986.00~~	168,705
Subtotal:	~~$728,806.00~~	843,525
Front-End Loader	40,000.00	
Alternative 'B' Total Costs:	~~$768,806.00~~	$883,525

Alternative 'C'

Alternative 'C', Figure 4, is a duplicate of Alternative 'B' except that a screw conveyor is utilized as the feeding mechanism. The coal/waste mixing percentages are the same as that for Alternative 'B' so the waste capacities would also be the same as would the need to exhaust steam to the atmosphere. The costs associated with this alternative are as follows:

Costs for Alternative 'C'
Firing Prepared Shredded Waste

Material	Cost	
28 Ft x 28 Ft Building	$ 39,200.00	
a. Lighting	10,000.00	
b. Foundations	10,000.00	
Effluent Receiving Hopper	5,000.00	
Effluent Belt Conveyor	20,000.00	
Magnetic Separator	10,000.00	
Bucket Elevator	25,000.00	
Effluent Container 100 Yd^3 w/Foundation	25,000.00	
a. Screw Conveyor	10,000.00	
b. Blower	20,000.00	
c. Pneumatic Conveyor	40,000.00	
d. Bag Vent	8,000.00	
Cyclone Separator	10,000.00	
a. Bag Vent	8,000.00	
b. Volumetric Feeder	2,500.00	
Effluent Container (Elevated) 20 Yd^3 w/Structural Steel	12,000.00	
a. (1) Screw Conveyor	10,000.00	
b. (1) Volumetric Feeder	2,500.00	
Controls and Interlocks	20,000.00	
Motors, Motor Starters, Etc. 47 Total HP	14,000.00	
Steam Exhaust System	15,000.00	
Economizer Flue Gas Bypass	7,500.00	
Total Material Costs	$323,700.00	
Construction Cost @ 50%	161,850.00	
Subtotal:	$485,550.00	
Construction Cost Contingency @ 15%	72,832.00	
Subtotal:	$558,382.00	
Design Fee @ ~~8%~~ 25%	~~44,670.00~~	139,596
Subtotal:	~~$603,052.00~~	697,951
Front-End Loader	40,000.00	
Alternative 'C' Total Costs:	~~$643,052.00~~	$737,951

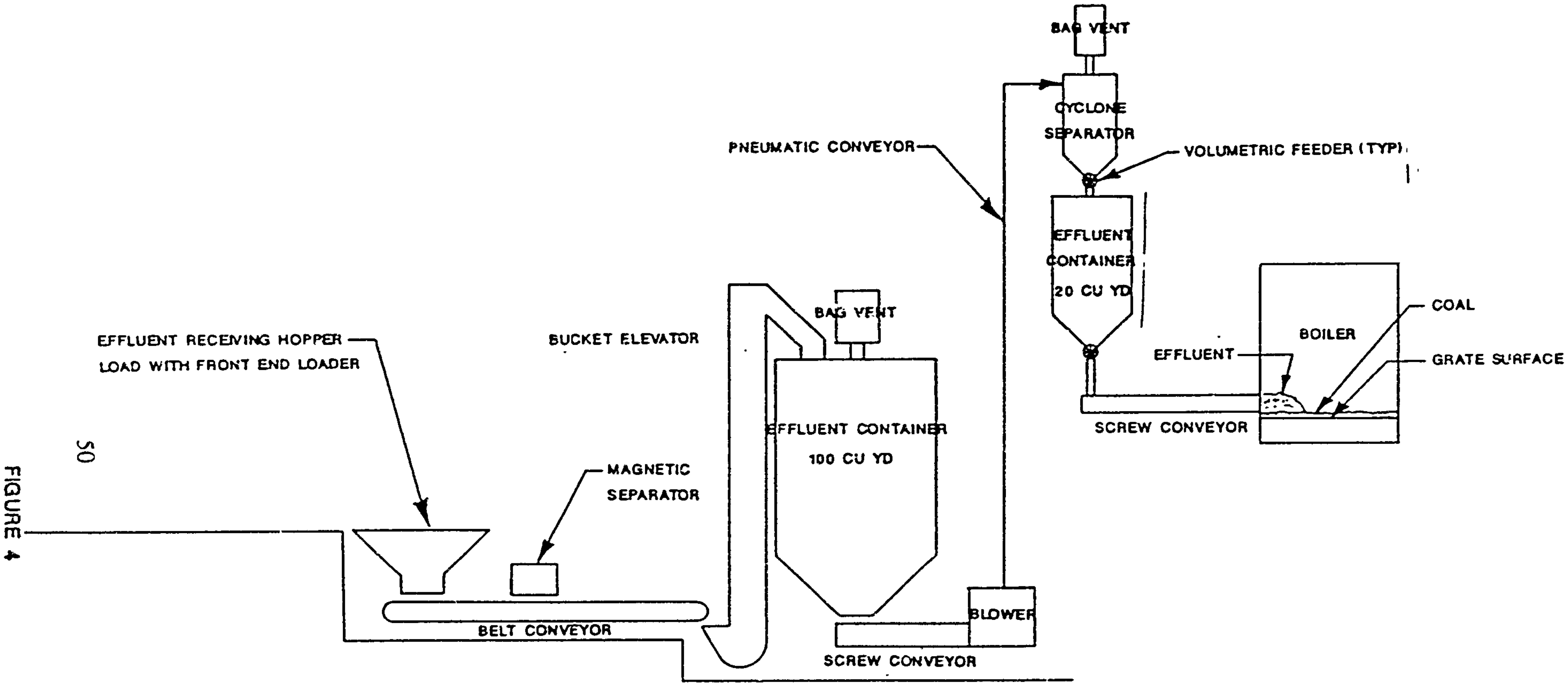


FIGURE 4

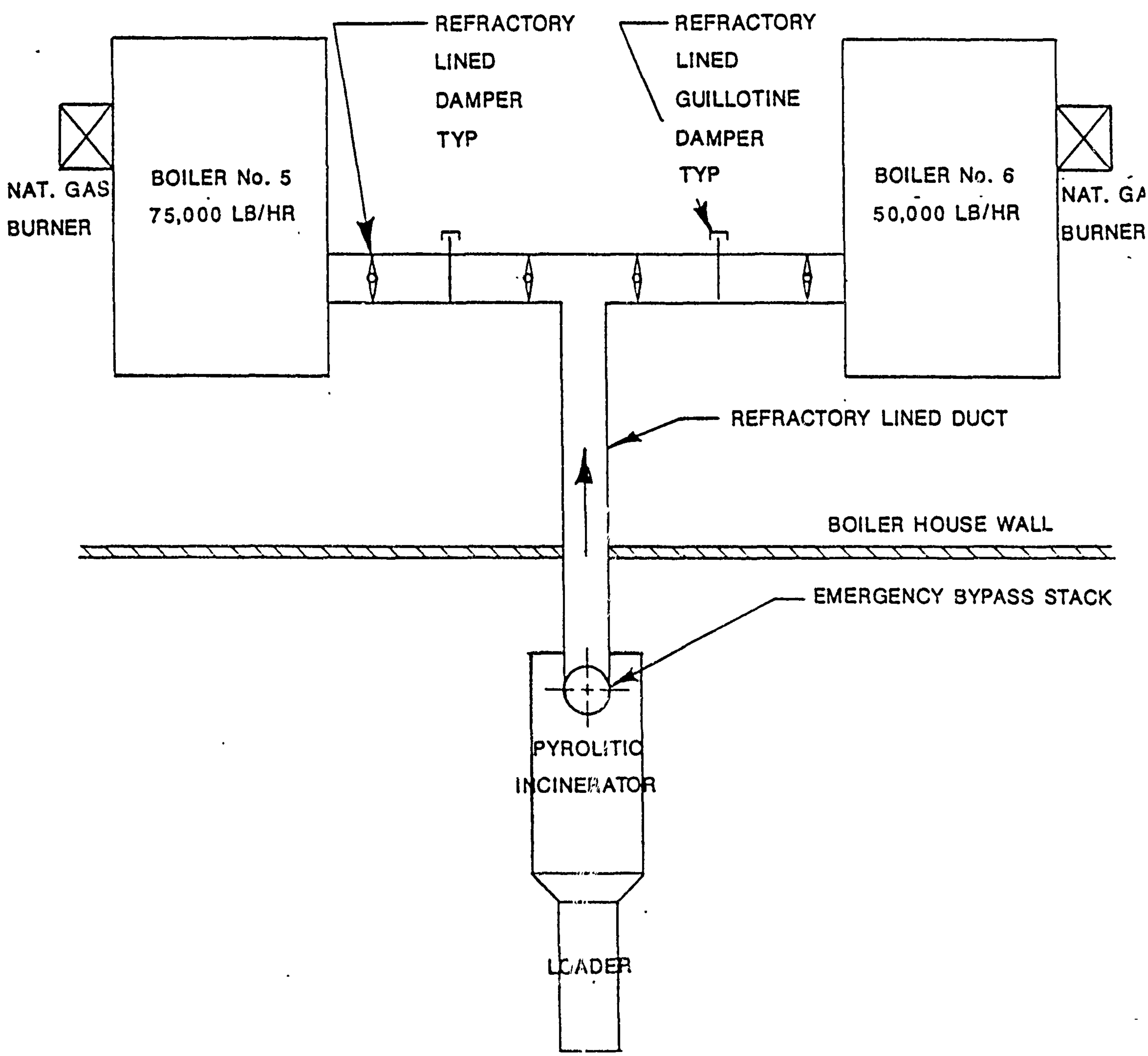
FIRING PREPARED SHREDDED WASTE
ALTERNATIVE "C"

Alternative 'D'

The option of utilizing an incinerator for the burning of the wastes and ducting the hot gases into the fifth zone of one of the existing chain grate boilers is shown in Figure 5 - Alternative 'D'. The only pollution control equipment required for this system, assuming that no plastics whatsoever will be burned, is the existing baghouse. The ash handling system for the incinerator would be tied into the existing system for the chain grate boilers. The boilers would be retrofitted with natural gas burners with capacities for maintaining up to 20,000 Lbs/Hr steam flow. The limited turndown capability while burning coal dictates the need for these natural gas burners in order to maintain header pressure while operating the incinerator at light plant loads. The costs associated with Alternative 'D' are as follows. It should be noted that the Comtro Model A-45 incinerator which was chosen by USACERL provides insufficient capacities. Comtro Model A-48 will provide the required capacity and allow a 24% safety factor at a higher cost of course.

Costs for Alternative 'D'
Waste Incineration

Material	Cost
44 Ft x 34 Ft Building	$ 74,800.00
a. Lighting	10,000.00
b. Foundations	10,000.00
Comtro Model A-48 Incinerator	522,000.00
a. Foundation	10,000.00
b. (4) Refractory Dampers	25,000.00
c. (2) Guillotine Dampers	20,000.00
d. Refractory Lined Ductwork	12,000.00
(2) Natural Gas Burners Pilot to 20,000 pph Capacity	58,000.00
Steam Exhaust System	15,000.00
Economizer Flue Gas Bypass	7,500.00
Controls	20,000.00
Total Material Costs	$ 784,300.00
Construction Cost @ 50%	392,150.00
Subtotal:	$1,176,450.00
Installation of Burners	80,000.00
Subtotal:	$1,256,450.00
Construction Cost Contingency @ 15%	188,468.00
Subtotal:	$1,444,918.00
Design Fee @ ~~8%~~ 25%	~~115,593.00~~ 361,230
Total Alternative 'D' Costs:	~~$1,560,511.00~~ $1,806,148



WASTE INCINERATION
ALTERNATIVE "D"

The following table provides material and construction cost comparisons for Alternatives 'A', 'B', 'C', and 'D'. The construction cost includes a design fee of 8%.

		Material Cost	Construction Cost	Total Cost
Alternative	'A' (Not Used)			
Alternative	'B'	$431,200.00	$337,606.00	$ 768,806.00
Alternative	'C'	$363,700.00	$279,352.00	$ 643,052.00
Alternative	'D'	$784,300.00	$776,211.00	$1,560,511.00

The technical and environmental feasibility of Alternatives 'B' and 'C' is dependent upon the success of their respective feeding mechanisms. Alternative 'B' utilizes the weigh larry car and the screw/belt conveyor setup for proper blending of the coal/waste mixture. Feeding the mixture is done in exactly the same manner as when feeding coal by itself. Whether or not this type of feeding will work properly depends upon the burning process of the fuel mixture on the grates. Burning of the waste will tend to occur more rapidly. Since the waste contains only 1.40% ash as compared to the coal which contains 6.59% ash, bare spots will develop on the grate surface and overheating of the grates with possible warpage will occur. Although some grate overheating/warpage occurs on most stoker fired boilers due to coal segregation etc., the grate surface has to be carefully monitored for any signs of potential interference with stoker/boiler operation. Due to the low ash content of the waste as compared to the coal, the chain grate boilers will have to be thoroughly tested to determine specific operating parameters required to maintain the integrety of the stoker/boiler system. These parameters will include the minimum amount of coal ash bed required to protect the grates which will determine the minimum coal feed (lbs/hr). In addition, the capacity of this alternative is limited to one weigh larry car trip every thirty minutes.

The following calculations provide grate heat release rates (Btu/Ft^2/Hr) at the estimated area of the grate surface of Boiler No. 6 where the screw conveyor feeding mechanism (Alternative 'C') will deposit the waste. At 14,000 Lbs/Hr steam flow (28% of Boiler Rating) which represents a waste burning capacity at 11.6 tons/day, the heat release rate is 810,000 Btu/Ft^2/Hr. At 26,000 Lbs/Hr steam flow (52% of Boiler Rating) which represents a waste burning capacity of 21.6 tons/day, the heat release rate is 1.5 million Btu/Ft^2/Hr. Recommended heat release rate at 100% of boiler rating is 650,000 Btu/Ft^2/Hr. This means that even if two feed locations were utilized, one on each side of the grate surface, at 26,000 Lbs/Hr steam flow (21.6 tons/day waste feed capacity), the heat release rate exceeds the recommended rate at 100% of boiler rating by 100,000 Btu/Ft^2/Hr. These heat release calculations render this alternative as technically not feasible.

Alternative 'C'
Heat Release Rate Calculations
Firing Prepared Shredded Waste
Utilizing Screw Conveyor Feeder

I. Fixed Data:

Efficiency Boiler No. 6	-	82%
Percent of Heat Input Waste	-	40%
Percent of Heat Input Coat	-	60%
Enthalpy Steam	-	975 Btu/Lb
Effective Coal Grate Area Boiler No. 6	-	136 Ft^2
Effective Waste Grate Area Boiler No. 6	-	9 Ft^2

II. Steam Load at 14,000 Lbs/Hr (28% of MCR):

A. Heat Input

$$= \frac{14,000 \text{ Lbs/Hr} \times 975 \text{ Btu/Lb}}{.82}$$

$$= 16.6 \times 10^6 \text{ Btu/Hr}$$

B. Coal Heat Release Rate:

$$\text{Rate} = \frac{.60 \times 16.6 \times 10^6 \text{ Btu/Hr}}{136 \text{ Ft}^2}$$

$$= 73,235 \text{ Btu/Ft}^2\text{/Hr}$$

C. Waste Heat Release Rate:

$$\text{Rate} = \frac{.40 \times 16.6 \times 10^6 \text{ Btu/Hr}}{9 \text{ Ft}^2}$$

$$= 737,777 \text{ Btu/Ft}^2\text{/Hr}$$

D. Total Heat Release Rate in 9 Ft^2

Area of Grate - 737,777 $Btu/Ft^2/Hr$
+ 73,235 $Btu/Ft^2/Hr$
810,012 $Btu/Ft^2/Hr$

III. Steam Load at 26,000 Lbs/Hr (52% of MCR):

A. Heat Input

$$= \frac{26,000 \text{ Lbs/Hr} \times 975 \text{ Btu/Lb}}{.82}$$

$$= 30.9 \times 10^6 \text{ Btu/Hr}$$

B. Coal Heat Release Rate:

$$\text{Rate} = \frac{.60 \times 30.9 \times 10^6 \text{ Btu/Hr}}{136 \text{ Ft}^2}$$

$$= 136{,}324 \text{ Btu/Ft}^2\text{/Hr}$$

C. Waste Heat Release Rate:

$$\text{Rate} = \frac{.40 \times 30.9 \times 10^6 \text{ Btu/Hr}}{9 \text{ Ft}^2}$$

$$= 1{,}373{,}333 \text{ Btu/Ft}^2\text{/Hr}$$

D. Total Heat Release Rate in 9 Ft^2

$$\begin{array}{lcr} \text{Area of Grate} & = & 1{,}373{,}333 \text{ Btu/Ft}^2\text{/Hr} \\ & & +\underline{\ \ 136{,}324} \text{ Btu/Ft}^2\text{/Hr} \\ & & 1{,}509{,}657 \text{ Btu/Ft}^2\text{/Hr} \end{array}$$

Alternative 'D' is technically the most feasible of the alternatives. Unfortunately, it is also the most expensive. Another drawback to this alternative is that, at light plant loads, the operating cost will be more than Alternatives 'B' and 'C' due to the fact that natural gas will be burned instead of coal.

APPENDIX D: SUMMARY OF LIFE CYCLE COST ANALYSIS (LCCID)

Session Number: 7

SUMMARY OF INPUTS

INSTALLATION NAME:	Lima Army Mod Center
REGION:	5
WASTE TYPE:	0
HEAT CONTENT:	8500
*WASTE QUANTITY:	5,200 lbs
DAYS/WEEK:	5
SHIFTS/DAY:	3
LANDFILL LIFE:	25 years
LANDFILL REPLACEMENT COST:	$0
*LANDFILL COSTS:	$80.69/ton
FUEL TYPE:	residual oil
*FUEL COSTS:	$1.90/MBtu
AUXILIARY FUEL TYPE:	natural gas
*AUXILIARY FUEL COSTS:	$4.76/Kcuft
ELECTRICITY COSTS:	3.9 ¢/KWh

* Value given differs significantly from the table value.
** NOTE: MBtu means MILLIONS of Btu's.

SUMMARY OF OUTPUTS

TONS PER 7 DAY WEEK OF WASTE:	100 tons/week
INDIVIDUAL INCINERATOR CAPACITY:	tons
NUMBER OF INCINERATORS REQUIRED.	
TOTAL FACILITY CAPACITY:	tons/day
CAPITAL COSTS:	$ /ton
APC CAPITAL COST:	$0/ton
HRI CONSTRUCTION COSTS:	$
O&M COSTS:	$25/ton
HRI O&M COSTS:	$130,000/year
LANDFILL SAVINGS:	$261,113/year
HEAT PRODUCTION:	45,177 MBtu/yr
FUEL COSTS:	$1.90/MBtu
AUXILIARY FUEL COST:	$4.62/MBtu
ELECTRICITY COST:	$11.37/MBtu
ENERGY RECOVERY FACTOR:	80.0%
NUMBER OF HOURS OPERATIONAL:	120 hours/week
NUMBER OF MBtu OF FUEL NEEDED PER TON OF WASTE BURNED:	0.374 MBtu/ton
GROSS FUEL SAVINGS:	$107,285.73/yr
YEARLY AUXILIARY FUEL COSTS:	$8,984.67/yr
YEARLY AUXILIARY FUEL QUANTITY:	1,946 MBtu/yr
YEARLY ELECTRICITY COSTS:	$7,619.86/yr
YEARLY ELECTRICITY QUANTITY:	674 MBtu/yr
NET FUEL SAVINGS:	$90,681/yr

** NOTE: MBtu means MILLIONS of Btu's.

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STEAM SUPPLY SUMMARY

Total Amount of Steam Produced:	[illegible] MBtu/year
Yearly Amount of Steam Produced:	45,17[illegible] lb/year
Daily Amount of Steam Produced:	173,742 lb/day
Hourly Amount of Steam Produced:	7,23[illegible] lb/hour

AUXILIARY FUEL REQUIREMENTS

Auxiliary Fuel Type:	natural gas
Fuel Requirements:	1,746 MBtu/year
Yearly:	1,888 Kcuft/year
Daily:	7.26 Kcuft/day
Hourly:	0.30 Kcuft/hour

OPERATING SCHEDULE SUMMARY

Incinerator Operation:	5 days/week 3 shifts/day
Daily Operation:	24 hours/day
Weekly Operation:	120 hours/week
Yearly Operation:	6240 hours/year
Effective Steaming Time:	24 hours/day

REFUSE DISPOSAL SUMMARY

Total Weight Disposed:	5,200 tons/year 100 tons/week 14 tons/day
Total Volume Disposed:	42.798 cuy/year

DISPLACED FUEL SUMMARY

Displaced Fuel Type:	residual oil
Amount Displaced:	56,466 MBtu/year 377,[illegible] gallons/year 1,451 gallons/day 60,45 gallons/hour

** NOTE: MBtu means MILLIONS of B[illegible]

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LIFE CYCLE COST ANALYSIS

PROJECT NO., FY, & TITLE: P000 FY 93 WASTE ...

INSTALLATION & LOCATION: LIMA AIP OHIO

DESIGN FEATURE: ALTERNATIVE EVALUATION

NAME OF DESIGNER: GRIGGS

SUMMARY REPORT

CRITERIA REFERENCE: FEMP/10CFR436A (Army TM 5-802-1, Para ...)

DISCOUNT RATE: 7%

ALTERNATIVES ANALYZED ALT. NO. DESCRIPTION/TITLE	LCC (NET PW) ($ X 10**3)	INITIAL COST++ ($ X 10**3)	AVG. ANNUAL ENERGY USE (10**6 BTUS)
A. LANDFILL	3439	0	56466
B. SHRED & BURN	1543	977	1864
C. BURN ONLY I	2368	795	916
D. BURN ONLY II	2159	664	743
E. HRI	3573	1382	15737

TABLE I. KEY DATA FOR ECONOMIC RANKING PURPOSES

++ INCLUDES PRE-BOD COSTS, IF ANY

ALT. ID.	INITIAL INVEST-MENT COSTS++	ENERGY COSTS	RECURNG M&R & CUSTODL COSTS	MAJOR REPAIR & REPLACE-MENT COSTS	OTH O&M COSTS & MONETARY BENEFITS	DISPOSAL COSTS OR RETENTN VALUE	TOTAL
A	0	1061	2378	0	0	0	3439
B	977	178	387	0	0	0	1543
C	795	88	1485	0	0	0	2368
D	664	71	1424	0	0	0	2159
E	1382	1006	1184	0	0	0	3573

TABLE II. LIFE CYCLE COST COMPARISON (ACTUAL NET PW VALUES)*

++ INCLUDES PRE-BOD COSTS, IF ANY

best available copy.

[illegible] LIFE CYCLE [illegible]
LCCID [illegible]
PROJECT NO., FY, & TITLE: 8000 [illegible]
INSTALLATION & LOCATION: LIMA ATP [illegible] OHIO
DESIGN FEATURE: ALTERNATIVE EVALUATION
NAME OF DESIGNER: GRIGGS

SUMMARY REPORT

INITIAL ALTERNATIVE NUMBER [illegible] (CUSTOM)	ENERGY COSTS	MACHINE PWR & CUSTODIAL COSTS	MAJOR REPAIR & REPLACEMENT COST	OTH O&M COSTS & MONETARY BENEFITS	DISPOSAL [illegible] RETURN VALUE	TOTAL	[illegible]	SPP
A. BASELINE ALTERNATIVE: ALTERNATIVE LOWEST IN INITIAL INVESTMENT COST								
B [illegible] 777	-862	-1992	0	0	0	[illegible]	[illegible]	[illegible]
C [illegible] 793	-973	-893	0	0	0	-1071	[illegible]	[illegible]
D [illegible] 664	-990	[illegible]	0	0	0	-1280	[illegible]	4
E [illegible] [illegible]	-55	-1194	0	0	0	133	[illegible]	19

TABLE III.A INCREMENTAL LIFE CYCLE COSTS* (RELATIVE TO GASOLINE)

** INCLUDES PRE-BOD COSTS, IF ANY

*NET PW EQUIVALENTS ON [illegible] IN [illegible] DOLLARS; IN CONSTANT [illegible]
*ENERGY ESCALATION VALUES FROM TABLES OF [illegible]

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APPENDIX E: TECHNICAL AND COST INFORMATION FROM SHRED PAX

CONRAD & ASSOCIATES, LTD.

2701 CHERRY STREET
PARK RIDGE, ILLINOIS 60068
~~(312)~~ 823-6275
FAX (708 ~~312~~) 318-7183

October 27, 1989

K.E. Griggs
U.S. Army Corps. of Engineers
P.O. Box 4005
Champaign, IL 61824

SUBJECT: Shred-Pax Shredder System - 25 T.P.D.

Dear Mr. Griggs:

In reference to our conversation, we are providing budgetary pricing for the shredding and handling of wood pallets and corrugated boxes to your boilers, including the equipment, as follows:

One (1) AZ 45-P Shred-Pax Shredder
One (1) AZ 15 Shred-Pax Shredder
Necessary mechanical conveyors
Oversize screening and recirculation
Storage Hopper for twelve (12) tons
Cyclone with fan
Piping
Dust Collector

Budgetary Pricing: $350,000 + or - 25%

We trust this will provide you with sufficient information for your project.

Very truly yours,

Conrad Michalowski

Conrad Michalowski

encls: Line Sheet
Shred-Pax Info.
cc: A. Kaczmarek, Shred-Pax
CM/

The efficient and economical reduction of bulk wastes into easy-to-handle scrap or recyclable resources is the job Shred Pax™ equipment was designed for. It's been doing it since 1970 when Shred Pax developed the first low speed, high torque shredder that literally tears solid objects apart with a pulling, tearing, shearing action of the counter-rotating, knife-equipped shafts.

From 800 pounds to 42,000 pounds per hour (depending on type of material) can be shedded and reduced or recycled. There's a just-right model for virtually any product: confidential documents, cardboard, wood pallets, cans, steel drums, tires, metal profiles, medical and nuclear wastes, to name a few.

From the biggest to the smallest, shredding machines can be delivered promptly by Shred Pax, the leading slow speed shredder and system manufacturer in the U.S.

The Shred Pax shredders are the most economical and simple to operate—and that's why they outsell any other low speed shredder in the world.

When your problem is reducing bulk and reducing waste handling costs, contact Shred Pax.

SHRED PAX SHREDDER MODELS (Partial List)

Model	Motor Drive	Model	Motor Drive
AZ-7	7.5-10 H.P.	AZ-45 Tire	40 H.P.
AZ-7 SNP	10 H.P.	AZ-45 Pallet	40 H.P.
AZ-15	15-20 H.P.	AZ-80	80 H.P.
AZ-15 SNP	20 H.P.	AZ-80 SNP	80 H.P.
AZ-15 Tire	20 H.P.	AZ-80 Tire	80 H.P.
AZ-45	40 H.P.	AZ-160	150 H.P.
AZ-45 SNP	40 H.P.	AZ-200	200 H.P.

SHRED PAX SHREDDER FEATURES

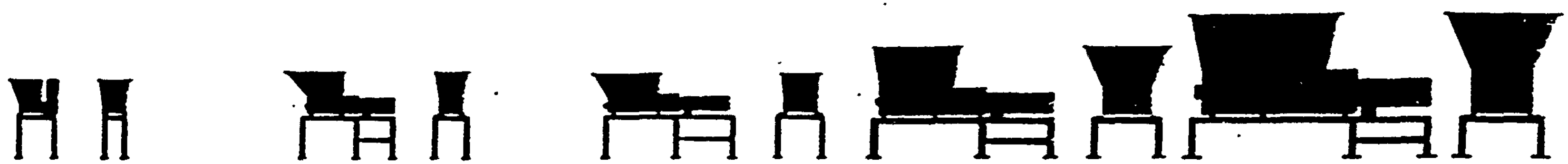
- Direct Drive—highest efficiency—no hydraulics—no hoses
- Low Maintenance
- Energy Efficient
- Simple Operation—one man (non skilled)
- Automatic Controls
- Quiet Running—under 80 Decibels—no sound proofing required
- Low Installation Cost—no foundations required
- Anti-jamming device—unshreddable "kick out" option
- Compact—minimal space required

shred pax corporation
136 WEST COMMERCIAL AVE.
WOOD DALE, ILLINOIS 60191-1304
PHONE 312/595-8780
TELEX 503654

REPRESENTED BY

CONRAD & ASSOCIATES LTD.
2701 Cherry St.
Park Ridge, IL 60068
312 - 823-6275

SHRED PAX™



SPECIFICATIONS

MODELS	AZ-7	AZ-15	AZ-45	AZ-80	AZ-160 AZ-200
Hp.	1-7½ or 1-10	1-15 or 1-20	2-20	2-40	2.75 or 2-100
Motor (s) -- 3 Phase	T.E.F.C.	T.E.F.C.	T.E.F.C.	T.E.F.C.	T.E.F.C.
Voltage	220/440	220/440	220/440	440	440
Hertz	60	60	60	60	60
Inside Dimension Cutting Chamber	14-1/8" x 16-15/16"	13-5/8" x 27-1/2"	20-5/8" x 42-1/8"	33" x 63"	44" x 96"
Shaft Diameter	41 mm	60 mm	85 mm	114.4 mm	140.3 mm
# of Knives	27	22	34	34	35
Standard Knife Thickness	15.5 mm	31 mm	31 mm	47 mm	70 mm
Dimensions (Machine Only) Dimensions shown are nominal and subject to change. If dimensions and/or specifications are critical, consult factory					
Height	34"	16-7/16"	17-1/8"	24"	39"
Width	21"	29-3/4"	38-15/16"	56"	71"
Length	32-1/2"	73"	99-1/4"	150"	196"
Stand & Hopper Height	as desired	as desired	as desired	as desired	as desired
Typical Hopper Opening					
Length	29"	41"	55"	69"	120"
Width	24-1/4"	25-3/8"	30"	70"	100"
Floor Space	20-5/8" x 31"	33" x 75"	40-1/2" x 101"	60" x 150"	71" x 196"
Weight (Approximate)	850 lbs.	1700 lbs.	4000 lbs.	25,000 lbs.	40,000 lbs.

SHRED PAX

APPLICATION CHART

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MODEL / APPLICATION	AZ 7	AZ 15	AZ 45	AZ 45P	AZ 80	AZ 160/200	AZ 300
PALLETS			■	■	■	■	■
ALUM TURNINGS	■	■	■				
ALUM CANS	■	■	■	■	■		
TRUCK TIRES					■	■	■
AUTO TIRES			■		■	■	■
PLASTICS	■	■	■	■			
METALS UNDER 16 Ga.			■	■	■	■	
STEEL TURNINGS	■	■	■				
STEEL CANS	■	■	■	■	■		
WHITE GOODS					■	■	■
HOSPITAL WASTE	■	■	■	■			
PHARMACEUTICALS	■	■	■				
MSW					■	■	■
GLASS	■	■	■				
CPO PAPER	■	■	■				
55 GALLON DRUMS			■		■	■	■
CORRUGATED		■	■	■	■		

■ Shred Pax Model most often recommended for this application.

This guide is based on average testing of the products listed. Actual shredder requirements may vary with specific needs

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EXCERPTS FROM

LOW-SPEED SHREDDER and WASTE SHREDDABILITY TESTS
conducted by E.G.& G. Idaho for Idaho National Engineering Laboratory, U.S. Department of Energy under D.O.E. Contract No. DE-AC07-76ID01570. Published April, 1983.

Shred Pax Shredder

This machine is manufactured by Shred Pax Corporation, Bensenville, Illinois. An electro-mechanically driven 80-hp Model AZ-80 shredder was tested. The one piece shredder is smaller and more compact than the other shredders tested. It has no hydraulic motors, pumps, and hoses, and it has only one control panel. The two electric motors are mounted on the frame with the shredder and gear box (see Figure 24). The gear box is designed to transmit the power of both 40-hp motors to each shaft. Therefore, when a cutter tooth encourages a tough-to-shred item, the power of both motors is used to effect the cut or shear. This is a 50% advantage over the one-motor-per-shaft concept used in the Triple/S Dynamics 400-hp and Saturn 617-hp shredders, which again allows the Shred Pax shredder to be built smaller. The hexagonal cutter shaft is only 4-½ in. across the flats compared to Saturn's 11-in. diameter shaft. The manufacturer claims this small shaft permits it to flex rather than break, allows the use of smaller bearings, permits the use of smaller diameter cutter wheels and because of these features, permits a smaller less massive machine. The intermeshed cutter wheels which have little clearance between them, are 17 in. in diameter and are 3-3/4-in. wide (see Figures 7 and 8). One shaft rotates at 20 rpm and the other rotates at 26 rpm.

This shredder's reversing cycle is slower and more deliberate than the hydraulic shredders. It stops when it encounters an unshreddable item, pauses for a second, and resumes shredding. This is because the electric motors actually reverse directions, while the electric motors on hydraulic units continue running and only the hydraulic motors are reversed.

This shredder generally took twice as long to process the various types of waste containers as did the Saturn 617-hp shredder; however, it reduced the waste to half the particle size, which is considered an equal trade-off on equipment capability.

A high-pressure gas bottle constructed from a 14-in. section of 4-in. stainless steel pipe welded at one end and capped and welded at the other end was placed in the shredder. Until this test, it had been considered unshreddable, but this shredder cut it into many small pieces, with a few backups. This was not the limit of shreddability for this machine.

Compared to the Saturn 307-hp model, the 80-hp Shred Pax model shredded two old typewriters and an old mechanical calculator without stalling, while the 308-hp Saturn shredder backed up six times.

Particle Size

Based on TWTF requirements, the Saturn 308-hp and Shred Pax 80-hp models both produced the best particle size. The Triple/S Dynamics shredder produced particle sizes that were too large for the TWTF. Saturn's 617-hp model produced marginally acceptable particle sizes, but could produce an acceptable size if narrower cutter wheels were used; however, this would result in a ~50% throughput rate loss. Many fine particles were created by all shredders, however, no dust was seen rising from any of the shredding operations.

Power Consumption

The two acceptable shredders for TWTF waste, the Saturn 617-hp model and the Shred Pax 80-hp model, were rated generally equal in their performance capabilities, however, the Shred Pax unit uses 7.7 times less horsepower than the Saturn unit. The following three major reasons account for most of this astonishing difference:

Use of hydraulic power causes an up-front calculated loss of ~31% efficiency when electric motor energy is converted to hydraulic power. The direct use of electric motors coupled to mechanical drives does not suffer this loss.

The Shred Pax unit uses a small shaft which permits smaller cutter wheels (8-½ in. radius versus Saturn's 13-½ in.) resulting in a 36% shorter moment arm which requires less horsepower to obtain the same cutting force.

Through gearing, the Shred Pax shredder has all of its 80 hp delivered to both (or to either) shaft when encountering unshreddable items. In contrast, the Saturn 617-hp shredder delivers only half the power to each shaft. Thus, the Shed Pax shredder gains a 50% advantage in this category. Figure 30 illustrates the significance of this point.

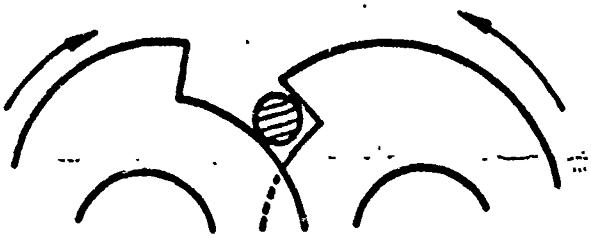

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Figure 30. A waste item (round bar) trapped and cut by one tooth against a non-tooth edge of the opposite cutter wheel. This situation occurs most frequently. The Saturn 617-hp shredder only applies half its power to this effort while the Shred Pax 80-hp shredder applies all of its power to this cut.

Calculated Maintenance

Since the Saturn and Triple/S Dynamics shredders are hydraulically driven, they require periodic maintenance on the hydraulic pumps, motors, and seals. The Shred Pax model is electromechanically driven and therefore does not have hydraulic maintenance requirements.

The Shred Pax machines use 5 or 10 year self-lubricating bearings. The bearing seals are very well protected and synthetic lubricants which can withstand 1000°F are used.

Purchase Price

The following is a list of shredder costs in 1981 dollars.

Blower Applications, 300 hp-$325,000

Triple/S Dynamics, 400 hp-$375,000

Saturn, 617 hp-$257,000

Saturn, 308 hp-$135,000

Shred Pax, 80 hp-$110,000

CONCLUSIONS

The Shred Pax 80-hp [illegible] considered the [illegible] for adaptability to [illegible] TWTF type [illegible] driven electrically rather [illegible] hydraulically, was competitive [illegible] the least expensive, had the lowest anticipated maintenance requirements, was the most energy efficient, and produced acceptable waste particle size.

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LORAMENDI	Core Machines: 0.2 to 7.0 cu.ft. capacity Complete Automated System Concepts from Core Blowing through Mold Assembly
NEW LONDON ENGR'NG	Bucket Elevators - Rubber, Wire Mesh; Slat & Hinged Steel Belt Conveyors - Power & Gravity Roller Conveyors - Chain Conveyor Systems For Robotic Automation - Automatic Carton & Tote Stackers
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CENTRAL MANUFACTURING	Rotary Separators - Radial Conveyors
SHRED-PAX CORP.	Shredders - Compactors - Recycling, Waste, & Pyrolysis Systems
PROFESSIONAL ENGR'NG ASSOCIATES, INC.	Vibratory Conveyors, Feeders, Bin Dischargers, Spiral Elevators, Direct & Indirect Heating & Cooling - Volumetric Belt & Screw Feeders - Vibra-Blend Mixers - Screw Conveyors
ENGINEERED ABRASIVES	Blast Cleaning, Finishing, Deflashing, & Stress Releaving Equipment - Media: silica sand, aluminum oxide, glass beads
MIDMARK CORP.	Charging Buckets & Ladles: all types & shapes
TRIPLE/S DYNAMICS	Fluidized Bed Separators - Vibrating & Disk Screens - Rotary Sizers
AUTOMATED SCALE CORP.	Mechanical & Electronic Scales For Every Application
BUFFALO MILL CORP.	Material Reduction
FABRI-TECH	Custom Design Fabricating & Assembly
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RAPID INDUSTRIES	Overhead Monorail Conveyor Systems
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